POWER PLANT ENGINEERING

Established Over 29 Years

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The Story of the Three Swans or Why the Lights Went Out

ONCE UPON A TIME there were three beautiful swans who had nothing in the world to do except fly around in sunny California in search of choice morsels to eat. One evening, after flying over the beautiful hills all day, they were tired and looked about for a suitable perch on which to rest. Finally they came in sight of a long line of high towers between which there were strung three shiny wires. "Now here," said the leader swan, "is a nice place for us to alight and rest. These shiny wires which the good people around here have undoubtedly put up for our especial benefit are just what we have been looking for. There are three of them so let us each rest on one." And so the three beautiful swans rested, and then—and then——. Well, folks, that's the end of the story—then the lights went out.

EPILOGUE

Afterwards, after ten thousand people in a distant city had clamored for lights and had given vent to certain opinions regarding the electric service in language which cannot be repeated here, a repair crew of the Pacific Gas and Electric Co., patrolling the back reaches of their transmission system, found the three swans and, incidentally, also discovered the cause of the short circuit. The beautiful swans, sad to relate, were quite dead.

IT IS STRANGE when we consider the great progress in power plant design that the boiler gage glass is still the same crude makeshift it was 40 yr. ago. Why doesn't somebody, surely there are plenty who could do it, invent a really reliable water level indicator that could be placed on the control panel where one could see it? Mr. Gray's article on gage glass illumination in this issue is good, but mere illumination can not be the ultimate solution of the gage glass problem. What we need is a new type of indicator —not a glass one.

Sioux City Gas and Electric Co.'s New Plant

TWO UNITS OF ULTIMATE 60,000-KW. BIG SIOUX STATION NOW IN OPERATION. PULVERIZED COAL, BLEEDER HEATERS AND UNUSUAL FEED WATER CONTROL ARE FEATURES

LAST JUNE the Sioux City Gas and Electric Co. put its new power plant, known as the Big Sioux Station, into operation. This plant was designed and built to carry the entire lighting, power and railway load of Sioux City, Iowa, and to serve the territory east of the city for a distance of over 100 mi.

Additional power generating equipment had to be located on a new site, as extending either of the two existing plants proved impracticable due to lack of condenser water supply. Both of the older plants depended, for their cooling water, on deep wells which were an expensive source, due to the power required and were becoming unreliable as the quantity was diminishing.

Various possible sites on both the Missouri River and the Big Sioux River were given careful study for a period extending over several years. The Big Sioux River site has the advantages of having well defined banks and the river confined to the present river bed, also relatively clear water. The bed of the Missouri River at Sioux City is exceedingly wide and with the recession of each year's high water, there is no certainty as to where the main channel will settle. Mud difficulties which have been encountered at other stations on the Missouri were a determining element in the decision to go to the Big Sioux site. The transportation facilities and housing situation along the Big Sioux were good. The only available site on the Missouri was some distance from the trolley line and there were poor roads and no houses.

The fact that this station will be the sole source of power for the district, and the older stations maintained for reserve capacity, dictated that the investment for the first step be kept at a minimum, so that the company could earn a reasonable return on the total investment of the plant, together with the previous expenditures on the two older stations which would be maintained for reserve capacity. The new station will also have the load factor of the system in place of a base load. This condition also limited expenditures for economy equipment.

Use of air preheaters was considered and the design was made so that they can be installed at a later date. Economizers equivalent to 38 per cent of the boiler surface, steam pressure of 355 lb. and a total temperature of 675 deg., together with two stages of bleeder heating are amply justified. The plant is designed for an operating efficiency of 17,000 B.t.u. per kw-hr. The equipment necessary for a lower B.t.u. consumption on the size and type of load would have proved too costly to show a reasonable return on the investment.

Several important factors led to the choice of the pulverized fuel method of coal firing. In this district, fuels of a widely varying quality are available and it is at times advantageous, financially, to change from one coal to another. The designers felt that no form of fuel burning apparatus which handles crushed coal could give or be rapidly adjusted to give uniformly high efficiency with varying grades of coal. There is also available a very fine coal, or mine sweepings, which has at the present no market except in the local cement mills. It is impossible to utilize this fuel for combustion under steam boilers, except in pulverized form. In order to enable the plant to take proper advantage of the fuel market conditions, it was advisable to adopt the pulverized fuel method of firing.

In the few weeks the plant has been in operation it has been found that a higher boiler efficiency of at least five points has been attained than could reasonably be expected with a stoker installation of either the underfeed or traveling grate type. Fuel bed clinkering troubles have become eliminated. The designers believe a greater flexibility of boiler rating and higher ratings can be acquired than is possible with a stoker installation.

COAL HANDLING

All coal is delivered by rail and the plant is equipped with track scales. The present storage system consists of locomotive cranes, one on the railroad track and the other with caterpillar tread for spreading. The coal is dumped into a track hopper and from there elevated to a short dis-

tance above the ground level to the crushers by means of a skip hoist. From the bottom of the crushers, coal is raised to the top of the coal tower with a second skip bucket.

It was necessary to break this coal handling into two steps due to the soil conditions, as quicksand is prevalent along the river bank and the expense of putting the crushers beneath the track hopper would have been materially higher than the plan adopted. This skip arrangement is novel in that only one winding machine and one cable is used. The first skip bucket serves as a counter balance to the second bucket. The power consumption and maintenance, therefore, are no higher using the double lift arrangement than they would be with a single skip bucket. The upper bucket discharges to a hopper which feeds the belts and these distribute the coal throughout the length of the mill building over the raw coal bunker, which is divided into three compartments. From the raw coal bunkers coal is spouted directly down through Wood dryers and from the Wood dryers to Raymond mills. The whole mill house equipment is grouped into three parts. Fuller-Kinyon pumps pump directly from the discharge of the mill cyclones to the pulverized coal bunkers over the boilers. The raw coal bunkers have a capacity of 90 t. each and the pulverized coal bunkers, a capacity of 75 t. each.

FIG. 1. COAL STORAGE SPACE IS COVERED BY LOCOMOTIVE CRANES

Boiler Plant Equipment

In the boiler plant at the present are three 11,120 sq. ft. Stirling class "P" boilers equipped with 4215-sq. ft. economizers. These boilers are baffled four pass and the Babcock & Wilcox type horizontal steel tube economizer is located beneath the fourth pass with a down gas circulation. The plant is so designed that when the load justifies the expenditure, air preheaters can be inserted in the uptake breeching from the outlet of the economizer and ahead of the induced draft fans. The induced draft fans are proportioned so as to take the additional resistance of the air preheaters. It is planned that the ultimate boiler plant will contain ten boilers of this same size to supply six 10,000-kw. units.

Steam pressure at the saturated drum is 355 lb. and superheat surface is installed to give a total temperature of 675 deg. at 200 per cent rating. The side walls and front wall of the boilers are of the Detrick construction with air passages for the secondary air. The type of construction adopted is that which is of the self-supporting type, each 2½-ft. belt of the wall being carried from the buck stays. The arch is also of Detrick construction and the operating floor is located above the arch so arranged that the top of the arch and the bottom of the operating floor form an air duct and the primary air for the burners is taken off from the top of the arch. This serves the dual

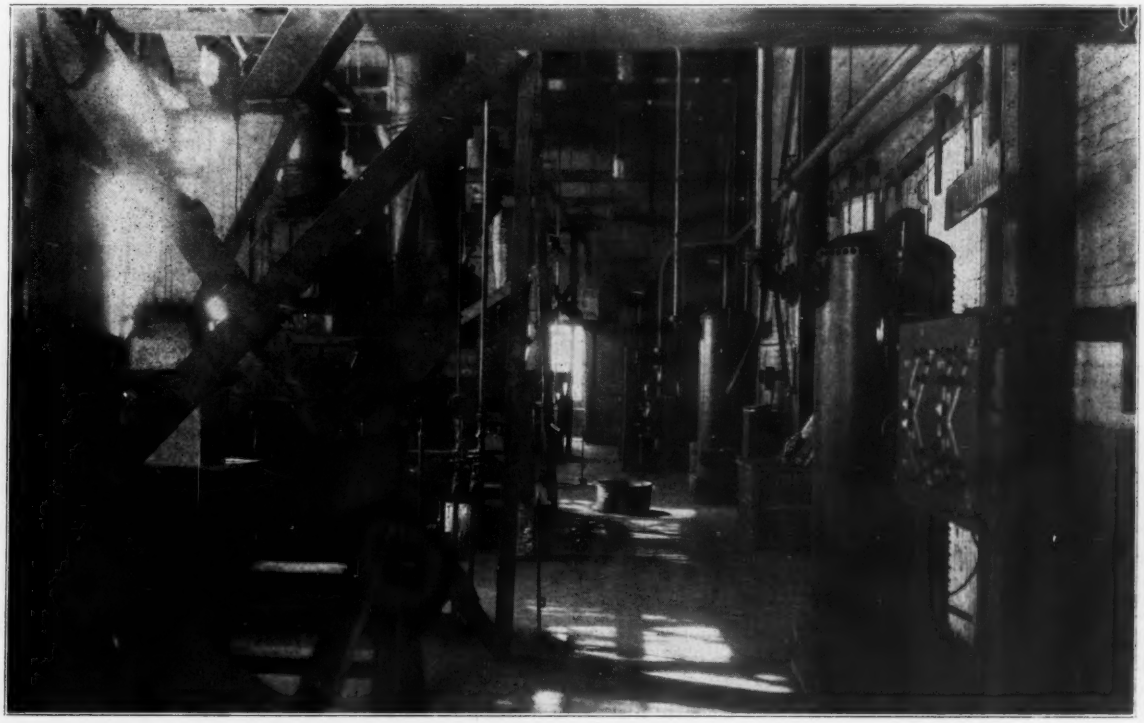


FIG. 2. THREE PULVERIZING MILLS ARE LOCATED IN A SEPARATE HOUSE

purpose of cooling the top of the arch and also eliminating the complication of bringing the primary air ducts up from the furnace bottom, which is a more usual type of installation.

Each boiler is equipped with seven burners which are driven by one direct current motor. The furnace bottoms are of the hopper type and ventilated, the air in these bottoms coming out into the boiler room. Each boiler is equipped with three air operated ash gates, the ash being discharged into a sluiceway at the bottom. The boilers are also equipped with a hearth screen which is 25 ft. down from the burner tips. This hearth screen is supplied at each end from connections from the mud drum of the boiler. It ties back through the bridge wall with return bends into the bridge wall screen, the tubes of which are carried up in the front bank of boiler tubes and again enter the circulation of the boiler in the front steam drum. In case difficulty is later encountered with side wall erosion, due to the type of ash, provision has been made to install side wall water screens and the front steam drums of the boilers have been extended to make this connection possible.

Each boiler is equipped with a single induced draft fan of the double width double inlet type. The fans are provided with two motors, one of 25 hp. which will carry the load up to 250 per cent and one 150-hp. motor which will carry the load up to 350 per cent rating. The motors are of the wound rotor type and have external resistors. The smaller motor has 21 equal speed steps and the 150-hp. motor 13 equal speed steps. There is an over lap of four speeds on the two motors.

All the high pressure steam piping, valves and fittings are in accordance with the new 600-lb. A. S. M. E. standard. This standard was chosen rather than the new 400-lb. A. S. M. E. standard as the dimensions conformed more nearly to the practice in the other plants in which The United Gas Improvement Co. is interested. The steam piping is all laid out on the unit system; two boilers supply steam to a manifold and one turbine takes its lead from this same manifold. The manifolds are tied together with

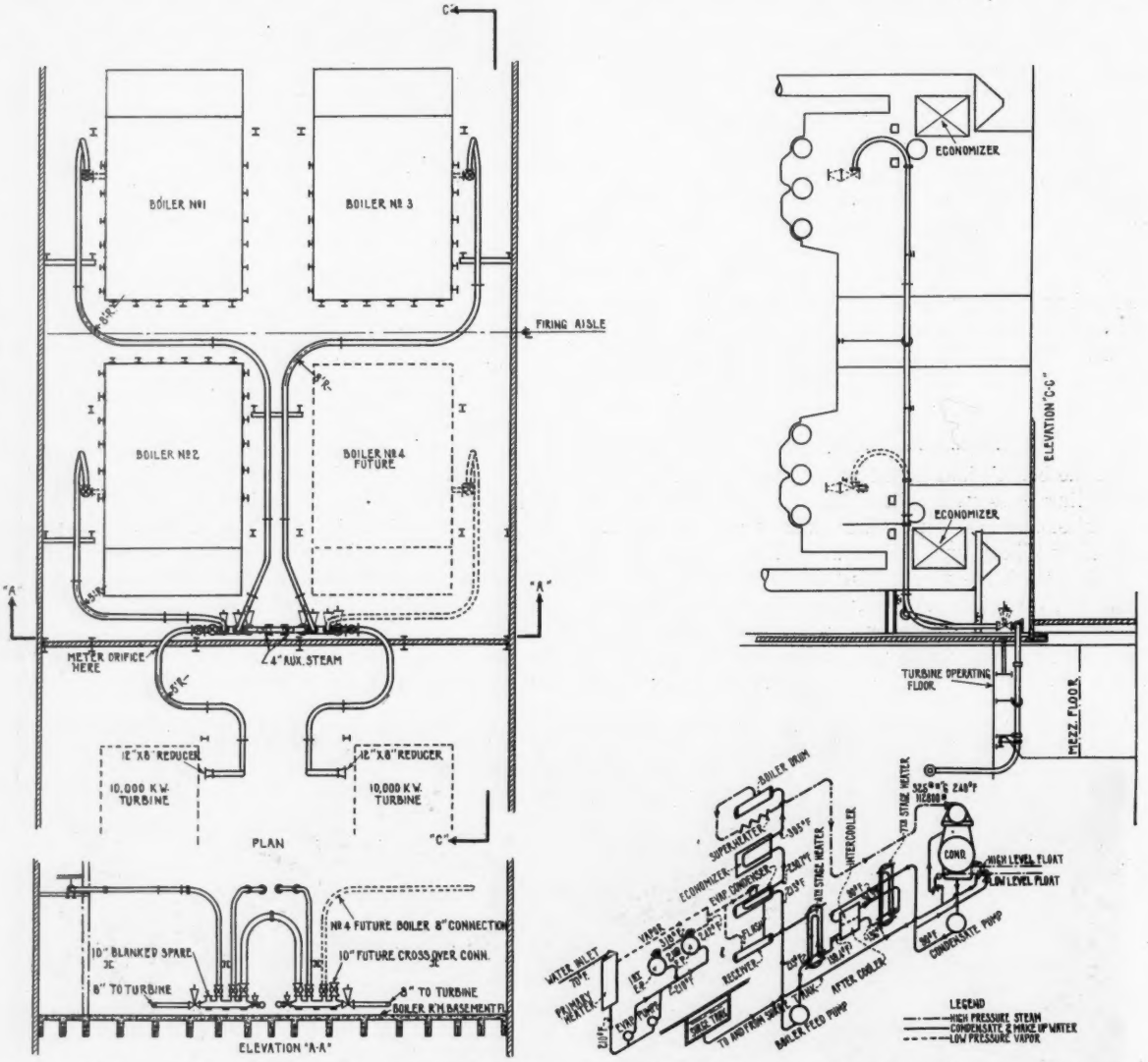


FIG. 3. MAIN STEAM PIPING, PLAN AND ELEVATIONS. SCHEME OF STEAM AND WATER PIPING SHOWN AT LOWER RIGHT CORNER

cross-overs and the auxiliary lines are connected to all manifolds.

The turbines are arranged for two-stage bleeding and are 12,500-kv.a. General Electric 9-stage machines. The steam end is designed to carry 12,500 kw. and the generators, 11,250 kw. at 90 per cent power factor. The condensers are of the Westinghouse Electric & Manufacturing Co.'s radial flow type. They have 17,000 sq. ft. tube surface and are equipped with two circulating pumps at single speed. It was found with this particular combination of turbine and condensers that a net saving could not be accomplished by having two speed circulating pumps, the increased steam consumption for lower vacuum, which would be obtained by decreasing the volume of water was greater than the horsepower saving realized by reducing the speed of the pumps. Each condenser is also equipped with a set of steam ejectors which consists of two primary jets and two secondary jets, together with inter and after coolers. These coolers are so piped as to use condensate, with the exception of one pass wherein circulating water is used for starting and at times of low load.

Feed Water System

In this station, the feed water system is of a novel design; the condensers are equipped with hot wells which are approximately 3 ft. deep and extend the full width and length of the condensers. The condensate pumps take their suction from these hot wells and pump through the bleeder heaters and inter and after coolers, directly to the suction of the boiler feed pumps. The boiler feed pumps deliver the water through the high heat level condenser of the evaporator system to the boilers. The boiler feed pumps are driven by constant speed a.c. motors but the drives for the condensate pumps are variable speed a.c. motors. The quantity of water discharged from the boiler feed pumps is controlled by varying the head on the suction, rather than by varying the speed or throttling the discharge. This variable head on the suction of the boiler feed pumps is obtained by varying the speed of the condensate pumps. The regulator which operates the speed control on the condensate pumps is actuated by an excess pressure regulator, that is, this regulator holds the boiler feed water pressure at 50 lb. in excess of the boiler steam pressure. The boiler steam pressure for this regulator is taken directly from the saturated drums.

This system has the advantage that the condensers were purchased with a definite guarantee of oxygen content per liter, which it was believed is below the point where danger from corrosion or pitting in the steel tube economizers or in the boilers can occur. It also lends itself to the elimination of elevated surge tanks, which are costly from a structural standpoint, and it tends to make the evaporator installation flexible, as there is no fixed point of temperature and pressure going to the high heat level condenser as is the case with an open feed-water installation.

In order to supply the necessary reserve water capacity the area between the foundations in the boiler room has been enclosed, making them into concrete surge tanks. In case the water level rises in the condenser hot wells, showing an excess in the system, it is possible to open a valve on the discharge of the condensate pumps so that they will discharge into the surge tanks. If, however, the water level in the condenser hot wells falls, showing a deficiency of water in the system, a valve can be opened which admits water from the surge tanks into the top of the condensers. In

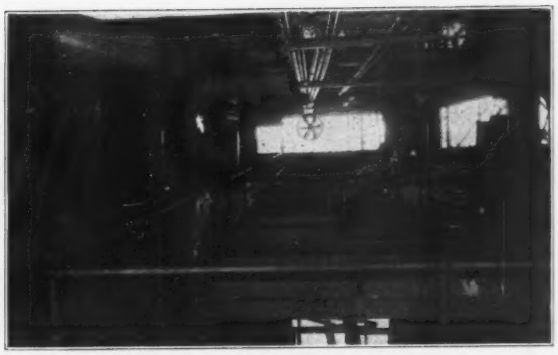


FIG. 4. BOILER OPERATING FLOOR IS ON GALLERY IN FIRING AISLE

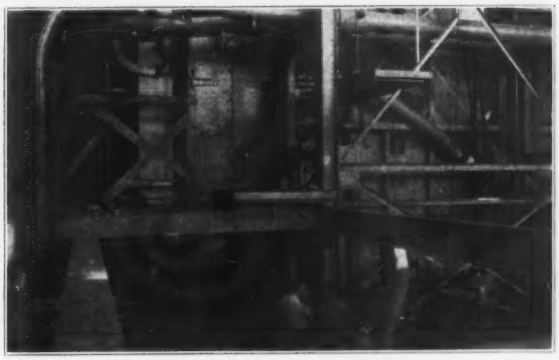


FIG. 5. STEAM PIPING LEADS TO HEADER AT REAR OF BOILERS

FIG. 6. EACH BOILER IS PROVIDED WITH A PANEL BOARD SUPPORTING STEAM FLOW AND DRAFT INSTRUMENTS

FIG. 7. MAIN STEAM VALVES IN BOILER ROOM ARE READILY ACCESSIBLE

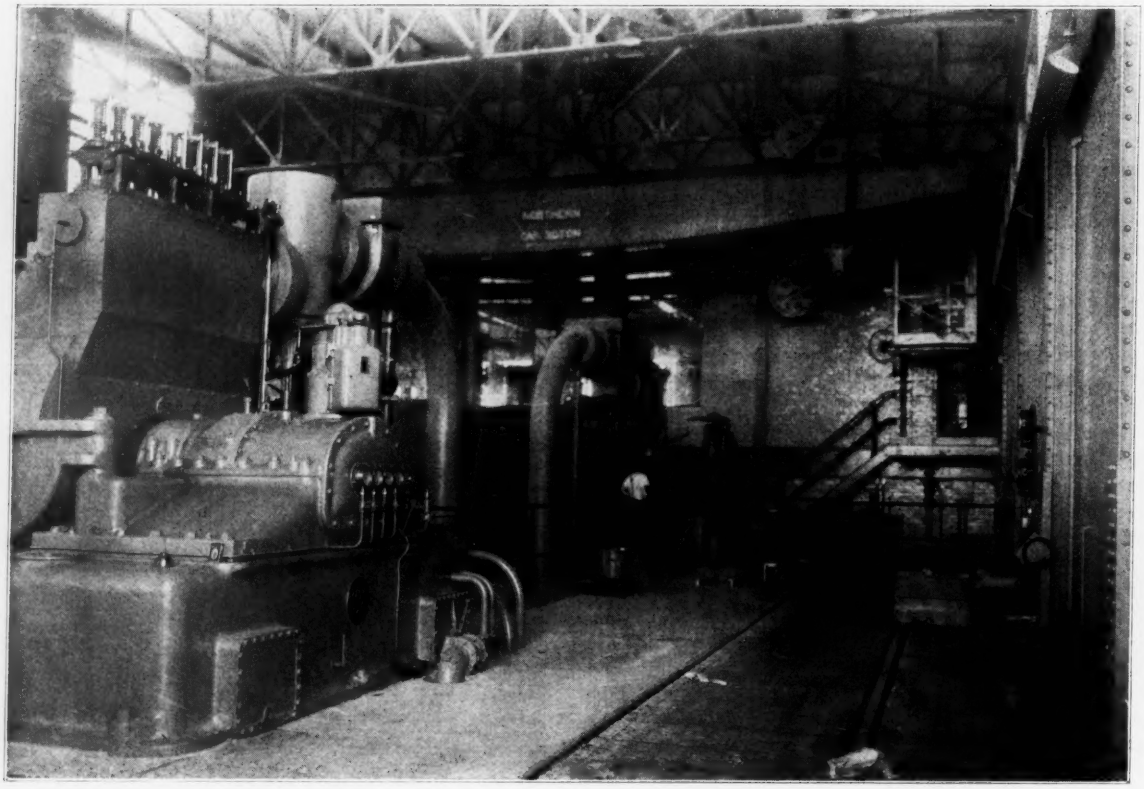


FIG. 8. PRESENT GENERATING EQUIPMENT CONSISTS OF TWO 11,250-KW. TURBO-GENERATORS PROVIDED WITH BLEEDER CONNECTIONS

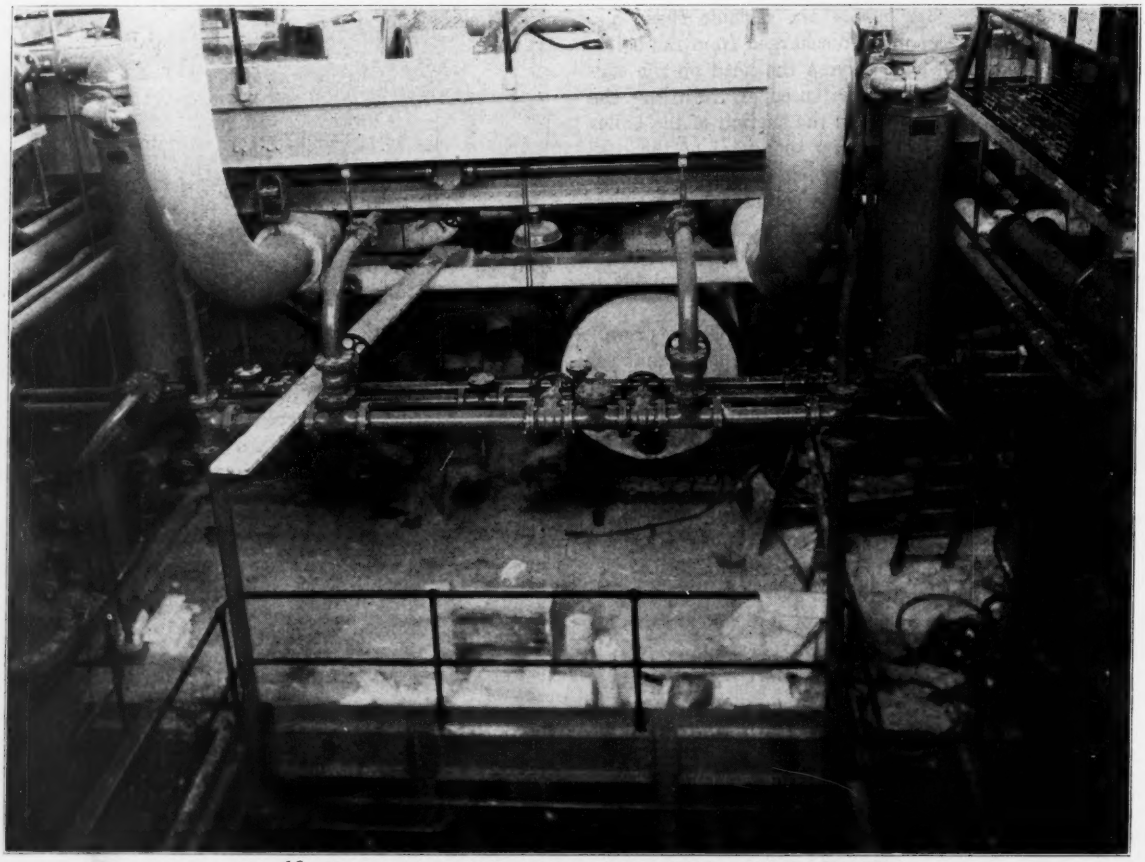


FIG. 10. VIEW FROM TURBINE ROOM FLOOR SHOWS BLEEDER HEATERS

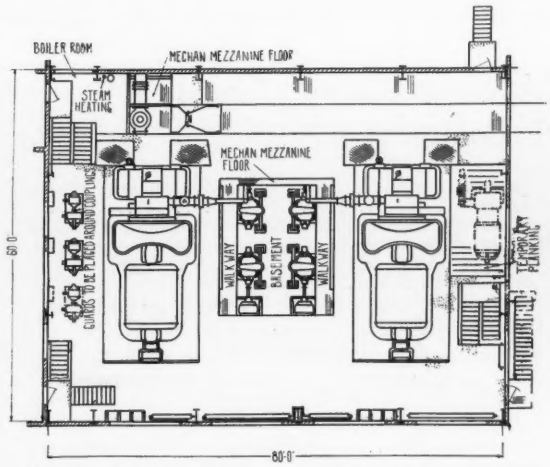


FIG. 9. SIMPLICITY MARKS ARRANGEMENT OF TURBINES AND AUXILIARIES

FIG. 12. ABUNDANCE OF LIGHT, BOTH NATURAL AND ARTIFICIAL, IS A NOTEWORTHY CHARACTERISTIC OF THE CONTROL ROOM

this manner, all water entering the system passes through the condenser. The two bleed points are at the fourth and seventh stages of the nine-stage turbine.

In order to safeguard against an electrical interruption which would stop both the condensate pumps and boiler feed pumps and jeopardize the supply of water to the boilers, a turbine driven boiler feed pump has been installed. This pump takes its suction directly from the surge tanks and discharges it directly into the boiler feed header. It is, therefore, necessary for this pump to supply the full boiler feed head while the motor driven pumps only supply the increment of head above that which is being supplied by the condensate pumps so that at their maximum point of 600 gal. per minute, the motor driven boiler feed pumps are supplying only 740 ft. of the total 1040 ft. head.

The steam driven boiler feed pump is brought into service by a regulator which also acts on the falling off of the excess pressure. This is so that the steam pressure and boiler feed pressure can vary over the full range without this pump operating, but a collapse in the difference in these pressures opens up the steam to the governor. To prevent difficulty from water hammer when steam is admitted to the turbine of the steam driven pump, steam is also admitted to a steam ejector on the boiler feed pump

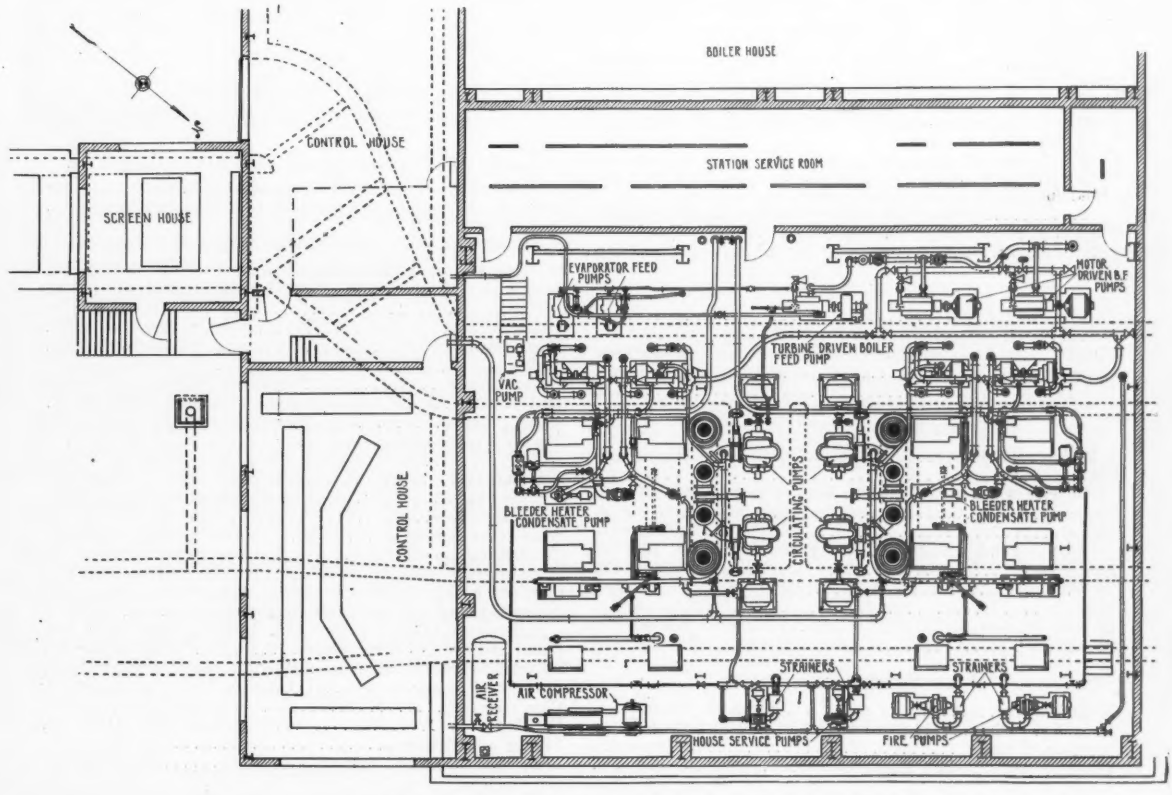


FIG. 11. PLAN OF THE TURBINE ROOM BASEMENT

Data on Principal Equipment in Big Sioux Station of Sioux City Gas and Electric Company

General

Location of plant	Sioux City, Iowa
Character of service	Light, power and railway
Capacity, present building, kv.a.	25,000
Ultimate kv.a.	75,000
Boiler house, ft.	100×81
Turbine room house, ft.	59×81
Control house, ft.	26×101
Mill house, ft.	22×81
General contractor	The U. G. I. Contracting Co.

Boilers, Superheaters & Economizer

Manufacturer	Babcock & Wilcox Co.
Type of boiler	Stirling, 4 pass.
Number installed	3
Steam-making surface per boiler sq. ft.	11,124
Furnace volume, cu. ft.	7810
Sq. ft. of steam-making surface per cu. ft. of furnace volume	1.425
Size of tubes	3¼ in. No. 8 gage
Boiler pressure, lb. gage	355
Superheating surface per boiler sq. ft.	2278
Ratio superheating to steam-making surface	1 to 4.88
Type of economizer	Duratex, Babcock & Wilcox Co.
Surface, sq. ft.	4215
Ratio economizer surface to steam making surface	1 to 2.64
Steam turns at 200% rating, deg. F	677
Corresponding superheat, deg. F.	240
Kind of fuel	Iowa Coal
Heat value, B.t.u. per lb.	10,000 on dry basis

Pulverized Fuel and Coal Handling Equipment

3 Mills	Raymond Bros. Impact Pulverizer Co.
Nominal capacity	6 tons
3 Dryers	Lopulco—Combustion Engineering Corp.
Surface, sq. ft.	288
3 Conveying pumps	Fuller-Lehigh Co.
Capacity, tons per hour	6
7 Burners, per boiler	Lopulco—Combustion Engineering Corp.
Drive	7½ hp. d.c. motor, 400—1600 r.p.m.
Type of coal handling	Belt conveyors and skip hoist
Furnished by	Link-Belt Co.
Capacity	40 t. per hour
Crushers, number	1
Crushers, make	Link-Belt Co.
Coal distributed in raw coal bunker	30-in. belt conveyor equipped with tripper
Method of reclaiming from storage	Locomotive crane
Manufacturer	Ohio Locomotive Crane Co.

Stacks

Number and type	2 self-supporting steel, lined full length with gunite
Height	44 ft. above roof, 69 ft. above burner floor
Diameter, inside	3 ft. 9 in.
Boilers per stack	2

Feed Water Equipment

3 Boiler feed pumps	Ingersoll-Rand Co. (Cameron)
Type	Centrifugal, 2 6-stage 740 ft. head, 1 4-stage 990 ft. head
Capacity	600 gal. per min.
Drive	2 General Electric 200-hp. motors, 1 Terry steam turbine, 250 hp.
Evaporator	1 Griscom-Russell Co.
Type	High pressure, 2 effect
Capacity	7500 lb. per hr.
Bleeder heaters	Griscom-Russell Co.
Surface, sq. ft.	4th stage 505, 7th stage 455

Main Generating Units

Manufacturer	General Electric Co.
Capacity, each	11,250 kw. at 90 per cent power factor
Number of units	2 (present)
Throttle pressure and temperature	325 lb., 675 deg.
Type of generator	3-phase, 60-cycle, 6600-v.
Ventilation	Closed system with Griscom-Russell Co. U-fin air cooler

Guaranteed performance of turbines:
Steam condition 325 lb. gage, 240 deg. F. superheat, expanded to 28.5 in. vacuum.

Load, Kw.	Lb. of Steam per Kw-hr.
5,000	11.7
7,500	11.0
10,000	10.8
11,250	10.85

Surface Condensers and Auxiliaries

Surface condensers	2 Westinghouse Elec. & Mfg. Co.
Tube surface, each, sq. ft.	17,000
Sq. ft. tube surface per kw. of generator rating	1.51
Connection to turbine	Rigid
Support	Springs
Condenser tubes	Scovill Mfg. Co
Circulating water pumps	Westinghouse Elec. & Mfg. Co.
Number per condenser	2
Speed	490 r.p.m.
Capacity, gal. per min., one pump	11,000 against 15 ft. head
Capacity, gal. per min., two pumps	19,000 against 23 ft. head
Drive	550-v., 75-hp., a.c. motors
Air ejectors	Westinghouse Elec. & Mfg. Co.
Number per condenser	2
Type	Jet with inter and after cooler
Steam consumption	1300 lb. per hr.
Capacity	34 cu. ft. of 70 deg. free dry air at 28½-in. vacuum
Condensate pumps	Ingersoll-Rand Co. (Cameron)
Number per condenser	2
Type	Cameron centrifugal, 2-stage
Capacity	300 gal. per min., 300 ft. head
Drive	Variable speed, 550-v., 60-hp., a.c. motors
Screen wells,	2
Traveling screens	Chain Belt Co.
Width of each screen	11 ft. 6 in.

Induced Draft Fans

Manufacturer	B. F. Sturtevant Co.
Number per boiler	1
Capacity, maximum	110,000 c.f.m. of 550° F. gas against 4-in. water pressure, or 90,000 c.f.m. of 360° F. gas against 4½-in. water pressure
Drive	2 wound rotor motors: 1—25 hp. and 1—150 hp.

Miscellaneous Equipment and Materials

Building steel	Mississippi Valley Structural Steel Co.
Steel sash and skylights	Detroit Steel Products Co.
Gratings	Arrowhead Co.
Firebrick	Walsh Fire Brick Co.
Sidewalls	M. H. Detrick Co.
Arches	M. H. Detrick Co.
Station crane	Northern Engineering Works
Soot blower	Diamond Power Specialty Corp.
Sump pumps	Ingersoll-Rand Co. (Cameron)
Bleeder heater pumps	Worthington Pump and Machinery Corp.
Fire pumps	DeLaval Steam Turbine Co.
Service pumps	Ingersoll-Rand Co. (Cameron)
Air compressor	Ingersoll-Rand Co.
Feed-water regulator	Northern Equipment Co.
Oil purification system	DeLaval Steam Turbine Co.
High-pressure gate valves	Chapman Valve Mfg. Co.
High-pressure globe valves	Crosby Steam Gage & Valve Co.
Recording and indicator instruments	Taylor Instrument Co.'s, Foxboro Co., Uehling Instrument Co.
Boiler meters and draft gages	Bailey Meter Co.
Steam flow meters	General Electric Co.
Boiler-feed water meter	Simplex Valve & Meter Co.
Pipe covering	Johns-Manville, Inc.
Packing	"Cranite"—The Crane Co.
Piping and fittings	The Crane Co.
Load indicating and signaling system	The Cory Co.

suction. This serves to heat the water going to the pump and also to supply additional suction head on the pump. The pump is also equipped with a steam coil in its suction which is supplied by leak off steam around the regulator to keep the pump casing and rotor warm at all times.

Air Coolers

The generators are equipped with Griscom-Russell U-fin type coolers, the source of water being directly from the condenser circulating pumps. With the two-stage bleeder heating additional thermal saving might have been made by circulating condensate, though this cooler was not sufficient to justify the additional expense and complication of piping up the two sources of supply. It would have been necessary to have had circulating water available for this cooler at times of light load and during a season of the year when the vacuum was below 28 in.

All of the rest of the auxiliaries in the plant are motor driven and it is planned to install a house turbine which will float on the emergency bus as a synchronous condenser during ordinary operation, and which will take up the load as a generator during an interruption to the house service.

All of the motors are a.c., 550-v. with the exception of the 7½-hp. motors driving the pulverized coal feeders. These are 250-v., d.c. The switching and sub-station is of the outdoor type with the transformers stepping up from the generator voltage of 6600 to 33,000, tied directly to the generator leads. The house service transformers then step down from the 33,000-v. bus to the 550-v. bus located in the service room inside of the building. From the 33,000-v. bus at the present time there are two feeders going to the older city plants which are used as sub-station.

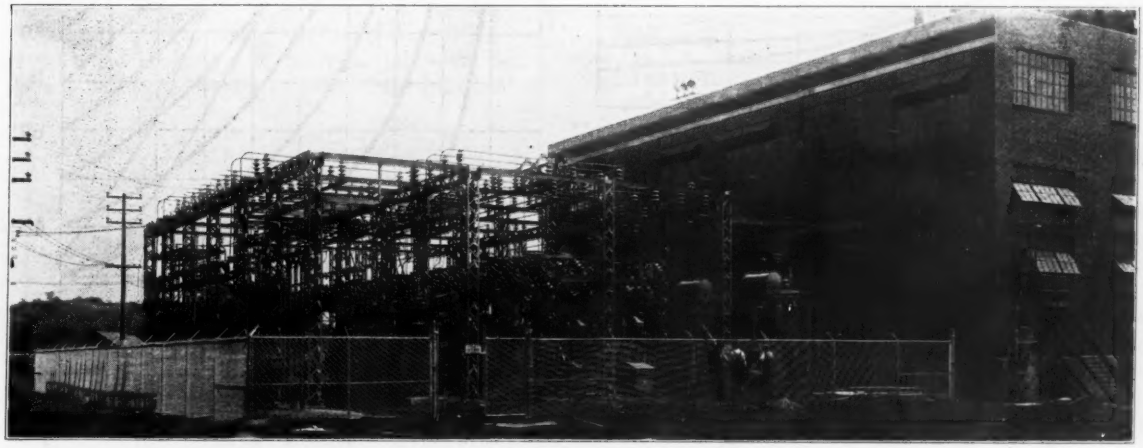


FIG. 13. TRANSFORMER AND MAIN SWITCHES ARE IN AN OUTDOOR SUBSTATION

Salvaging the heat in coke as it comes from the gas retorts is a plan to be put in operation by the Rochester (N. Y.), Gas & Electric Corp. The process, which originated in Switzerland some 5 yr. ago, consists of placing the hot coke in brick lined containers of 90-T. capacity and drawing inert gases over it into standard boilers. Heat is thus transferred from the coke to the steam, reducing coke temperature from 2000 deg. F. to 500 deg. Treatment of 385 T. of coke a day is estimated to produce 115 T. of steam a day. The plant, which will cost $250,000, will be erected at the West Station.

First Multiphase Induction Motor Retired from Service

AFTER MORE than 30 yr. of operation, the first multiphase induction motor to be placed in commercial operation on a central station line in this country is to be retired from active service and will be used by the General Electric Co. as an historical exhibit. This company recently completed arrangements with the Page Belting Co. of Concord, N. H., for the return of the old motor to Schenectady. The motor had been driving a group of machines through line shafting in the Page Belting Co. plant.

This motor was the first sold of the General Electric Type "TI" line first marketed in 1893. It was rated 5 hp., 1500 r.p.m., 110 v., 50 cycles, 3 phase, four poles and was originally sold to N. P. Stevens of Concord, N. H., on September 7, 1893. Mr. Stevens used the motor in his machine shop until his death in 1910, when his son closed out the shop and sold the motor to P. C. Shute, Concord, in November of that year. In 1914 the motor was again sold, this time to the Ford Foundry Co. of Concord, from whom it was purchased in March, 1917, by the Page Belting Co., in whose plant it was in service until June 15, 1925, when it was returned to the General Electric Co., which built it.

The motor was in almost continuous service for nearly 32 yr., the early years of service being on a 50-cycle circuit. In 1900 the circuit was changed to 60 cycles.

When the motor was placed in operation, the power to run it was purchased from the Concord Land & Water Power Company, now the Concord Electric Company. This company had installed a temporary generator rated 35 kw. which was used pending delivery of two 50-cycle, 2200-v., water-wheel generators then on order with the General Electric Co.

Steel tanks set upon the ground should be placed upon a bed of sand over the top of which has been spread a liberal quantity of crude oil. This precaution, in a large measure, prevents rusting and corroding of the tank bottom.

Steam Power in Its Relation to Water Power*

THERE ARE FEW HYDRO-ELECTRIC DEVELOPMENTS WHERE THE COST OF POWER CANNOT BE REDUCED BY THE ADDITION OF SOME STEAM POWER. BY RICHARD C. POWELL

IT IS A SIMPLE economic fact that the value of an article which has reasonable life and which can be reproduced in quantity is determined not by the costs of the article itself, but by the costs of the same article manufactured subsequently. And, furthermore, the cost of a substitute finally determines the value for the article when no longer capable of successive reproduction. Economically considered, water power is an article of interminable life apparently capable of successive reproduction in

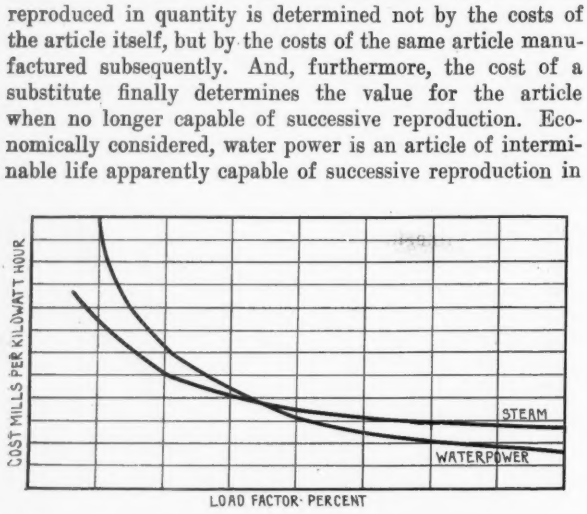


FIG. 1. TYPICAL COST CURVES FOR STEAM AND WATER POWER

the form of the development of new sites, but in reality an article of limited availability whose value must finally rest upon that of some substitute.

Many of our existing water power developments were developed under financial limitations which required a minimum of first cost. The electric light and power industry today, however, is, on the whole, upon a free economic basis and is no longer forced to uneconomic practices on account of inability to finance properly. For this

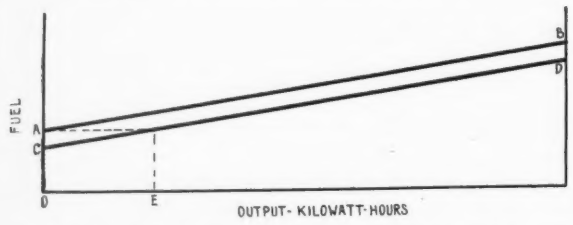


FIG. 2. CHARACTERISTIC RELATION BETWEEN FUEL AND STEAM OUTPUT FOR A STEAM PLANT

reason it is probable that most future projects will be developed on a comprehensive economic basis and will be developed to a somewhat greater extent than if considered alone.

In this article it is desired to call attention to the economic possibilities in the proper employment of water power in conjunction with steam power to the end that economic studies for the development of water power will include consideration of steam power.

The usual method of comparing the costs of water and steam powers is by means of curves similar to those shown in Fig. 1. Let c stand for the annual cost of water power in dollars per kilowatt delivered. The cost of water power per kilowatt-hour, W, may then be expressed as follows:

$$W = c \div (8760\,f) \qquad (1)$$

where f is the use factor.

In the same manner the cost of steam power per kilowatt hour is given by

$$S = \frac{a}{8760\,f} + b \qquad (2)$$

where a = (fixed charges on the investment + (the cost of operation and maintenance) + (the cost of fuel to keep the plant hot with turbines turning over and operation of the auxiliaries), all as annual costs per kilowatt of station capacity, and, b = the fuel cost per kilowatt-hour.

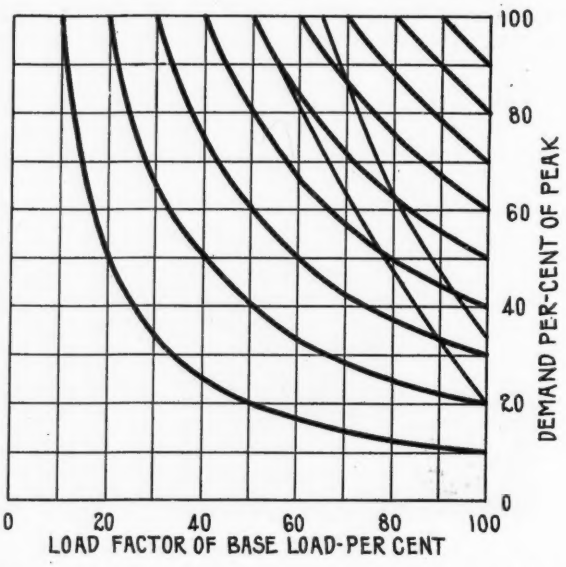


FIG. 3. RELATION BETWEEN LOAD FACTOR AND DEMAND FOR BASE LOAD

The relation between fuel and kilowatt-hour output for a steam plant is linear as shown in Fig. 2. The line A B gives the fuel for the net kilowatt-hour output. For a plant using O E kilowatt-hours for the auxiliaries, the line C D gives the fuel for the gross output. O A is the fuel which enters into the term a and b is the slope of the line, either A B or C D.

It is apparent from the curves in Fig. 1, that, in general, water-power gives lower cost for high load factors while steam has the advantage for low load factors. It must be noted, however, that the cost curve for steam-power is correct for all load conditions while that for water-power is not. In general, this cost curve for water-power does not show the relation between cost per kilowatt-hour and load factor, but that between cost per kilowatt-hour and output. Unless the output as a function of time (output curve) coincides with the load as a function of time (load curve), this cost curve is not correct. The conditions for correctness are:

1. A constant stream flow.

*Presented at the Pacific Coast Convention of the American Institute of Electrical Engineers, Seattle, Wash., Sept. 15-19.

2. A varying stream flow with flow curve similar to the load curve.

3. A regulated stream flow.

Of these three cases, (1) is very rare, Niagara being an example, (2) is not known to exist while (3) is not unusual.

It is very seldom that water-power can be developed at such a low cost that some steam-power will not lower the costs of generation. An exception is the case of a reasonable cost water-power of constant stream flow or a regulated flow plant supplying a load having a load factor approaching 100 per cent. The reason for the ability of steam-power to reduce the cost of generation is quite clear when one considers that (1) the load may be split into two parts by taking off a given percentage of the peak, one part being the so-called "base" load and the other the "peak" load and that (2) the load factor of the base load may be anything from 100 per cent to that of the total load, and the load factor of the peak may be anything from zero to that of the total load. And further, that by proper division of the total load and with the base load on water-power and the peak on steam, a minimum cost for power will result.

If p be the proportion of the peak taken on steam, 1 — p will be the proportion of peak of the base load on water-power. Let q be the proportion of the kilowatt-hours taken on steam. Then the cost of power per kilowatt-hour is, by combining equations (1) and (2)

$$p = \frac{c\,(1-p) + a\,p + 8760\,f\,q\,b}{8760\,f}$$

Reducing and putting k for 8760 f, that is, the kilowatt-hours delivered per kilowatt of demand

$$p = \frac{c}{K} - \frac{(c-a)\,p}{K} + b\,q \qquad (3)$$

This equation is simple and all that is needed to make it workable is a relation between p and q. This can be done with a fair degree of accuracy with the chart shown in Fig. 3. All that it is necessary to know is the peak load, minimum load and the load factor. The theory of this chart will be clear by referring to Fig. 4. Assume a load curve of the shape A B C F E D having a portion E F representing an instantaneous peak without kilowatt-hours. If a portion of the peak is taken off such as E G then the load factor of the base load will change but not the kilowatt-hours. Hence, if the percentage of the peak for the line C D is y and that for the point G is x then the load factor of the load with a peak G is given by

$$f = y \div x$$

The series of curves in Fig. 3 is plotted from this equation. Since an actual load curve must increase in kilowatt-hours as the percentage of the peak is increased, it follows that in tracing on this diagram the curve of relation between load factor and peak for the base load, such a curve must continually cut the curves of the diagram. Once having this curve for the peak load remaining together with the percentage of these kilowatt-hours to the total load is readily obtained. If the curve traced is not approximately correct this will be apparent on the curve plotted to show the relation between p and q in equation (3).

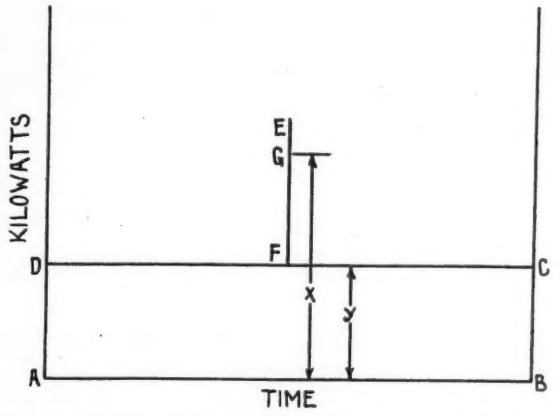


FIG. 4. LOAD CURVES TO EXPLAIN THEORY OF CHART, FIG. 3

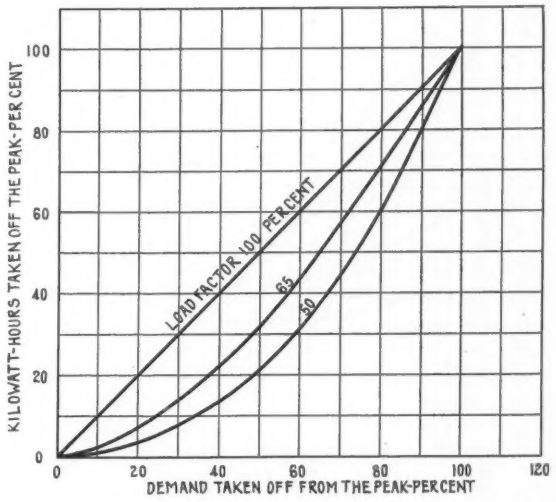


FIG. 5. RELATION BETWEEN PEAK AND KW-HR., TAKEN FROM A LOAD CURVE BY TAKING OFF A PORTION OF THE PEAK

In Fig. 3 are shown two traces for loads of 65 and 50 per cent load factors and minimum loads of 33 and 20 per cent respectively. The corresponding p q curves are given in Fig. 5.

With equation (3) and the assistance of the p q curves the values for plotting the curves of Fig. 6 were calculated. These curves are given to show in a general way, how the cost of power is affected by variations in the costs of water-power and fuel. For the cost of steam-power, the following conditions are assumed; oil as the fuel and at full load a kilowatt-hour for 15,000 B.t.u.; steam plant costing $90.00 per kw.; standby fuel 2.5 bbl. per kw. per year and output at 450 kw-hr. per bbl.; operation and maintenance at $3.50 per kw. per year. The cost of water-power is taken at $35.00 and $40.00 per year per kilowatt of output.

It is readily seen that the conditions favorable to a minimum of steam are low cost hydro development, high fuel cost and high load factor. With a 65 per cent load factor which is higher than that of most systems, with oil at $2.00 per bbl. which corresponds to coal at about $8.00 per ton, and with water-power at $35.00 per year per kw. of output, the minimum cost of power is obtained when

20 per cent of the peak is carried on steam. In this case the cost of generation is reduced 3 per cent as against the case with no steam power. For the same assumed costs and a system load factor of 50 per cent the minimum cost of power obtains when steam carries 50 per cent of the peak and in this case the cost of generation is reduced over 13 per cent as against all water-power.

More important, however, than the reduction in unit generating cost is the reduction in capital required for generating and transmitting facilities. In the case of 20 per cent steam-power under the conditions assumed, only 80 per cent of the capital is required as for an all water-power generation, 10 per cent reserve capacity assumed in both cases. And in the case of 50 per cent steam-power, the corresponding capital amount is reduced to 60 per cent.

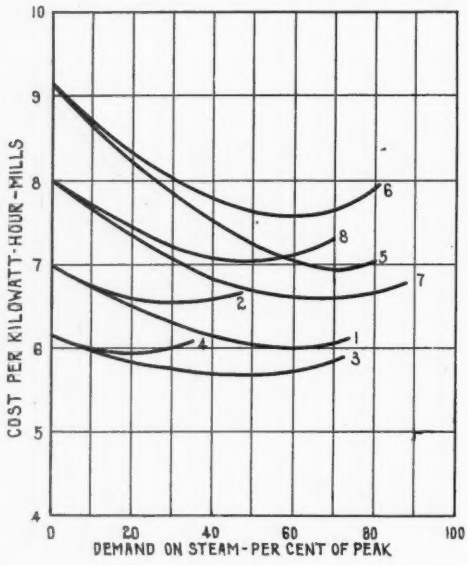


FIG. 6. VARIATION OF POWER COST WITH COST OF WATER-POWER, FUEL AND LOAD FACTOR

Curve Number	Cost: Water-Power Dollars per year per kw. demand	Cost: Fuel per bbl.	Load Factor
1	40	1.50	65
2	40	2.00	65
3	35	1.50	65
4	35	2.00	65
5	40	1.50	50
6	40	2.00	50
7	35	1.50	50
8	35	2.00	50

In general, the preceding equations and curves cannot be applied directly in actual practice because most systems will have some plants where storage is expensive or not feasible and the output will, therefore, vary according to stream flow. Furthermore, the available hydro kilowatt-hours may be less than the amount presupposed by the curves. This will be apparent from the following example. In Fig. 7 is the graph of the combined monthly kilowatt-hour output for a number of existing and projected water power plants, some of which have flow regulation. The "mean year output" curve is the average monthly kilowatt-hour output for the year for which records are available, and the "dry year output" curve is that for the dryest year to date. The peak output is 575,000 kw., with an annual delivery of 3600 million kw-hr. costing $35.00 per year per kw. of generator demand. If the load factor is taken as 65 per cent and oil at $2.00 per bbl. the curves give a minimum cost of generation of 6 mills for 20 per cent of the peak on steam. However, the curves are based upon a delivery factor for the hydro of 75 per cent, whereas from the data just mentioned this factor is only 71.5 per cent. Furthermore, instead of generating 310 million kw-hr. by steam as shown from the curves, actually 500 million kw-hr. must be carried by steam. It is evident, therefore, that while the cost curves discussed above may be useful in many cases, they are not general and must be used with discrimination.

Referring again to the system output shown in Fig. 7, if no steam-power is employed, the system load which can be carried will be limited by the kilowatt-hour output for the month of August in a dry year. The limiting load will be that having a system peak of 465,000 kw. and is shown in Fig. 7. If a system peak greater than this is

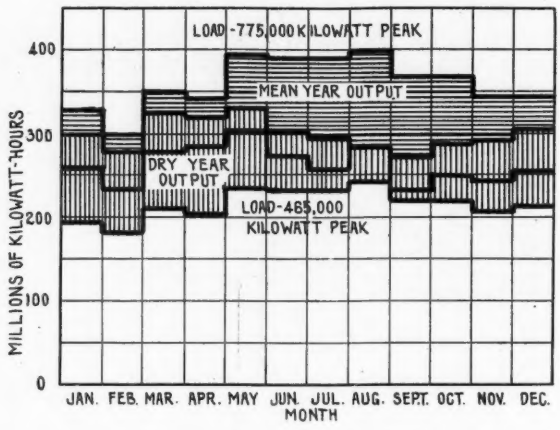


FIG. 7. KILOWATT-HOUR LOAD AND WATER-POWER OUTPUT CURVES

taken, steam-power will be required to make up the deficiencies in peak and kilowatt-hours. By taking a number of assumed peaks, the required size of steam plant and number of kilowatt-hours generated by steam are easily found. The total costs of generation may then be readily determined and a curve or tabulation will show the load that should be carried for minimum generating cost. The process is simple and requires no further explanation.

The load curve for a peak of 775,000 kw. is also shown in Fig. 7. It is now easily seen from the figure why the use of steam-power reduces the cost of generation. With no steam-power, the kilowatt-hours represented by vertical cross-hatched area between the "mean year output" curve and the "load, 465,000-kw., peak" curve cannot be used because the load will not absorb them. When steam kilowatt-hours represented by the horizontal cross-hatched area between the first mentioned curve and some given load curve which in Fig. 7 is taken for a peak of 775,000 kw., then 1000 million kw-hr. from water power become available by the generation of 720 million kw-hr. by steam, or for the cost of 720 million kw-hr. by steam 1720 million kw-hr. are obtained.

In the curves of Fig. 8 is shown the final result, one for oil at $2.00 per bbl. which is reasonably high, and the other for an extremely high price for oil of $3.00 per bbl.

Minimum costs occur for system peaks of 800,000 kw. and 675,000 kw. with oil at $2.00 and $3.00 per bbl. respectively and the corresponding steam plant capacities are 325,000 kw. and 200,000 kw.

The application of steam power to this particular water power development effects the following economies, assuming oil at $2.00 per bbl.

1. Reduces the cost of generation 1.5 mills per kw-hr. or 17 per cent.

2. Reduces the investment 15 per cent or 35 million dollars for the load of 800,000 kw.

This covers the minimum cost for a given assumed development of a group of water-power sites. The absolute minimum will of course be obtained only by an extended study involving the costs for a number of assumed hydro outputs.

The price of fuel will undoubtedly increase continuously to higher levels. This situation will permit an automatic adjustment of the economic ratio of steam- to water-power; for if the price of fuel increases while the cost of water-power additions are not materially increased, the ratio is lowered by discontinuing additions to the steam plants. Referring to Fig. 8, it is seen that for an increase of 50 per cent in the cost of fuel the economic ratio is reduced from 40 per cent to 30 per cent and the 325,000 kw. steam capacity for a load of 800,000 kw. will now be sufficient for a load of 1,100,000 kw. provided the cost of the additional water-power capacity is not greater than that for the existing water-power. Thus, the probable increase in fuel costs contributes in every way to the stability of water-power development and makes its economic development sounder from the financial standpoint. Nevertheless, with the increasing value of fuel, it may be safe to say that steam plants of high efficiency should be constructed.

To summarize the preceding: The development of our water-power should be along comprehensive lines involving in every case studies of other available water-powers and the economic place of steam-power; the usual cost curves for steam- and water-power apply in practice to special cases only and extended studies are required in order to arrive at the economic development of water-power and the economic ratio of steam-power; the employment of steam-power will in most cases lower the cost of generation and reduce appreciably the capital expenditures; and finally the consideration of steam-power as an economic factor in the development of water-power will undoubtedly postpone beyond the time of some recent estimates the construction of the last water-power plant.

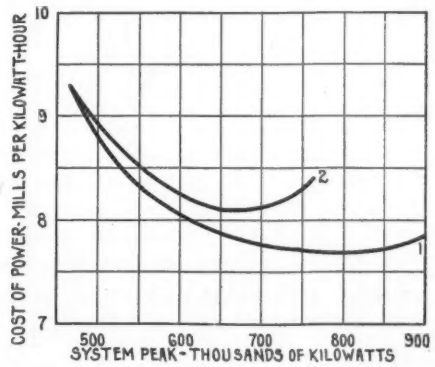


FIG. 8. VARIATION OF POWER COST FOR VARIOUS LOADS. COST OF FUEL $2.00 PER BBL. FOR CURVE NO. 1 AND $3.00 PER BBL. FOR CURVE NO. 2

Illumination of Gage Glasses

PRINCIPLES OF LIGHTING GAGE GLASSES DEVELOPED BY EXPERIMENT. BY L. R. GRAY

UNTIL the advent of the modern high settings for boilers, little attention was paid to the illumination of gage glasses. An electric globe was placed somewhere in the neighborhood of the gage glass and by its light the water level could be seen. In case of doubt, the try-cocks were opened and their indication relied upon.

But as the water columns of modern boilers were placed higher and higher above the boiler room floor, it became increasingly difficult to observe the water level in the gage glass and to be certain that there was no mistake in the observation. At the same time the higher pressures made the indications of the try-cocks uncertain. This meant that many times the man in charge of the boilers was not sure exactly where the water level was.

This condition, of course, could not be allowed to exist if any means could be found to avoid it. So we find on the market today various devices intended to bring an indication of the water level down to the boiler room floor. There have also been installed in many boiler rooms combinations of mirrors and periscopes intended to provide a better view of the gage glass. The writer, however, has always been rather distrustful of any device for the indication of so vital a thing as the water level. So, when confronted with the above conditions, some thought was given to improving the direct view of the gage glass itself.

Figure 1 shows the general arrangement of the boiler room. The water column is located about three-fourths of the way from the floor to the roof. Directly over the firing aisle is a monitor with windows on each side which admit light and air. It was observed that at certain times of the day the water level could be clearly seen, while at others the gage glass was only a silver streak and the water level could not be seen at all from the boiler room floor. It was also noticed that sometimes the water level could be seen just as well with the lights turned out as with them turned on. All this evidently invited study.

In Fig. 2 is shown a more detailed view of the conditions of the gage glass. The line of sight when looking at the gage glass is indicated. The electric light is located about as shown. It will be seen that the light from the skylight re-enforces that from the electric light at a slightly different angle; so the same analysis will serve for both.

Since both the inside and outside of a gage glass are highly polished surfaces, they serve well as mirrors. Thus light from the electric light will be reflected from the

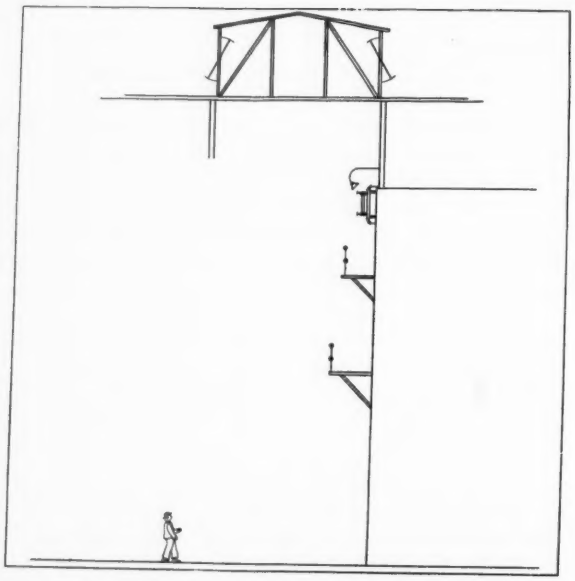


FIG. 1. GENERAL ARRANGEMENT OF LIGHT SOURCES AND OBSERVER IN ORIGINAL INSTALLATION

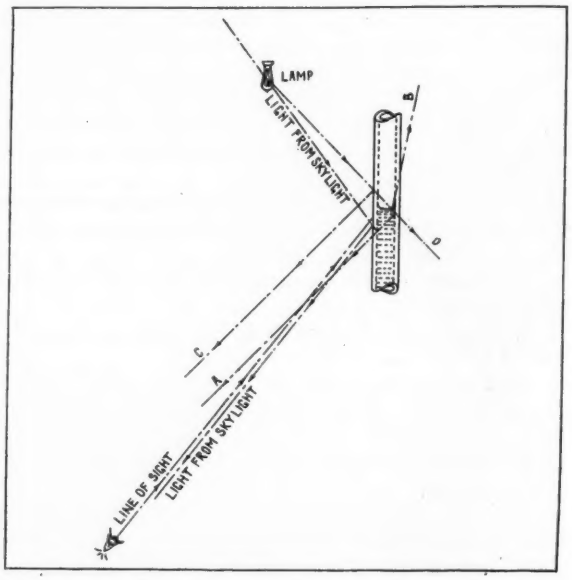


FIG. 2. DETAIL OF ARRANGEMENT SHOWS CONFUSION OF LIGHT RAYS

front of the outer surface as shown at C. There will be a glare reflected directly into the eye no matter where the water level is. When the sun is in the right position to shine through the window directly onto the gage glass this component predominates and is enough to prevent any view of the water level. At other times its effect will not be so bad, but it will always tend to reduce the visibility.

That part of the light which is not reflected from the outer surface of the gage glass as at C, passes through it, where same is reflected from the inner surface of the glass as at A and the rest passes on through as at D. At the water level a portion is reflected from the top of the meniscus as at B.

Thus it will be seen that of the total light, only two components, A and C, ever reach the eye. Of the two, A is the weaker since it must travel through two thicknesses of glass and the water. Yet it is the only one which is affected by a change in the water level. What we wish to see is the image of the surface of the water as seen in component A. To do this it is necessary that the direction of A be along the line of sight. This is not exactly the case in Fig. 2, but it would be if the water were a little higher. One can readily see that the view of the water level will be more plain at some points in the gage glass than at others. Obviously, this method of illumination does not produce the most favorable results; so different arrangements were tried and analyzed in a similar manner.

It was soon found that it did little good to put the light at the side of the glass or at the middle because there was no component thrown in the line of sight. If the light was put below the glass and in front of it, the observer had to look directly into the source of light to see the gage glass and was thus partly blinded. The same was true when the light was located above the glass and behind it. When, however, the light came from below the gage glass and behind it, we had different conditions, as shown in Fig. 3.

Here it will be seen that component C, the blinding one, and component A, the weak one, now go away from the eye. Component B is reflected from the bottom of the meniscus directly to the observer. The meniscus is a wonderfully effective mirror and produces such a striking effect that its position is unmistakable. Besides this, light

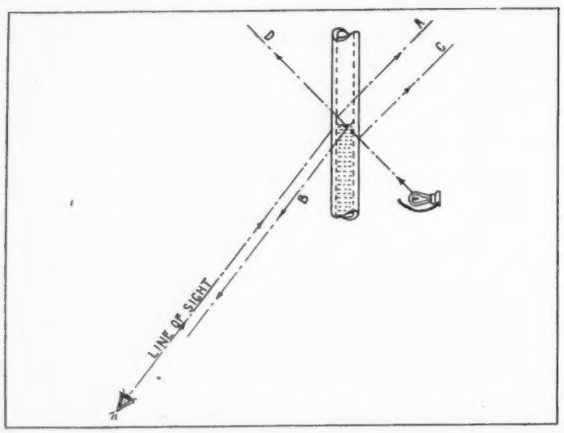


FIG. 3. LIGHT FROM BENEATH AND BEHIND THE GLASS MAKES WATER POSITION UNMISTAKABLE

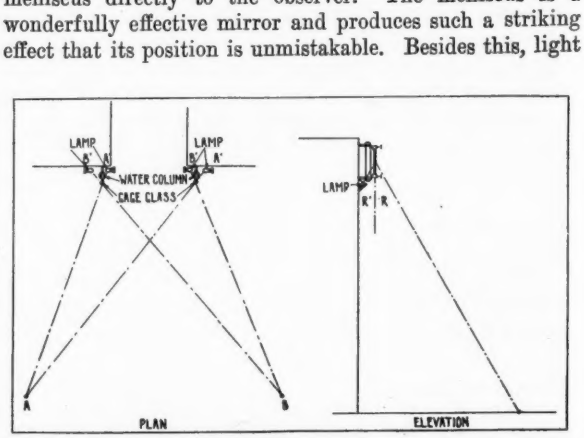


FIG. 4. PLAN AND ELEVATION DEMONSTRATING PRINCIPLES OF LIGHTING ARRANGEMENT

is refracted through the water and causes it to appear colored. We now have the water presenting a different appearance from the space above it; the top of the water is strongly emphasized and stray light in the eyes is reduced. Since these are the desired results, this is the proper arrangement.

Glare, caused by the light from the window in the monitor, has not been stopped, it is true, but the visibility of the water level has been so greatly improved that it can be seen in spite of the glare, in most cases. If not, a shade can be put about where the light is shown in Fig. 2, but this will seldom be necessary.

After thus finding the proper arrangement for one particular boiler room, the general principles were worked out which should give good results in any other conditions. These are the rules:

Locate the most convenient point from which to observe the gage glasses.

Then put the light behind the gage glass in such a position that the light, the gage glass and the eye will all be in the same vertical plane. The plan of Fig. 4 shows the proper location of lights for two water columns and two positions. When looking from point A the lights should be at A'. When looking from point B, the lights should be at B'.

The elevation shows the relationship in this plane AA'. The light should be below the glass so that angle R equals angle R', and should be shaded so as to throw all the light on the gage glass.

These rules were tried out in the installation of two other boiler rooms and in each case gave the same results, i. e., the water seemed lemon colored with a bright star floating on it. In one case the results were so satisfactory that, although periscopes were provided, they were not installed because they were not needed, even though the water column is almost 50 ft. above the floor.

Why Pay High Prices for High Gravity Fuel Oil?

HEAVY OIL IS CHEAPER, HAS MORE HEAT UNITS PER BARREL AND RESULTS ARE JUST AS EFFECTIVE IF PROPERLY HANDLED. BY D. S. FRANK

AMONG THE USERS of fuel oil there seems to be a large number who, although strongly in favor of burning oil in preference to other fuels, are entirely unaware of the merits of a heavy grade of oil or are unduly prejudiced in favor of a light grade.

In addition to a considerable difference in the price of the two grades of oil, there is also a difference in both the weight per gallon and the heating value. A B.t.u. is a B.t.u., whether contained in a pound of heavy fuel or in a lighter grade, but since fuel oil is sold by the barrel the B.t.u. content per barrel and not per pound should be the basis for purchase. A barrel of oil contains 42 gal. regardless of the number of pounds it may contain. For example, a fuel oil of 18 deg. Be. contains 7.882 lb. per gal. (A. P. I. Table) and has a heating value of 18,920 B.t.u. per lb. The total B.t.u. in a barrel of this fuel oil is 6,263,353. Fuel oil of 26 deg. Be. contains 7.481 lb. per gal. and has a heating value of 19,240 B.t.u. per lb. or 6,045,247 B.t.u. per bbl. Subtracting the total heat units in the 26 deg. Be. oil from the total in the 18 deg. Be. oil, there is a difference of 218,106 B.t.u.

HEAVY OIL HAS MORE HEAT AND COSTS LESS

A safe margin of cost would be approximately 1 cent per gal. or 42 cents per bbl. In other words, with 26 deg. Be. fuel oil selling at $1.62 per bbl., one could get 18 deg. Be. oil for $1.20 per bbl. In buying the 26 deg. grade the purchaser receives 6,045,247 B.t.u. for $1.62, while on the other hand if he purchases the 18 deg. Be. fuel, he not only saves 42 cents per bbl., due to the difference in the costs of the two fuel oils, but also he gains 218,106 B.t.u. per bbl. In terms of money this amounts to an additional saving of about 6 cents per bbl. The total saving would then be 48 cents per bbl. With a total consumption of 200 bbl., the daily saving would be $95.60, or in plants operating continuously throughout the year, would amount to $34,894.00.

There is only a slight increase in the heating value of different gravity fuel oils, while at the same time there is a decided increase in the pounds per gallon as the oil becomes heavier. This also means an increase in the viscosity of the oil and makes the problem of handling somewhat more difficult. An 18 deg. Be. fuel oil should be heated in the fuel oil tank to between 180 and 200 deg. F. When possible, the oil should be transmitted underground to the pump and then either underground or in fully insulated pipes to the burners. The cold test usually is about zero, so this gravity oil should not give any trouble in the coldest weather. Due to the bottom settlings forming an emulsion with the oil, the suction pipe from the tank should be provided with a swing which should always be kept above the level of the sediment.

LEVEL OF SEDIMENT DETERMINED BY SPECIAL GAGE

This level may readily be determined with a box "thief" gage. If such a device is not available, an iron pipe heavily chalked on one end, for a distance approximately the depth of the sediment, and lowered into the tank to the bottom, will give a fair indication of the amount of sludge and water. Except for discoloration, the oil will not affect the chalk but the sludge and water will remove it from the end of the pipe.

If the consumption is small or if the line has a dead-end, some trouble will be experienced with congealing of the oil in cold weather. In order to obtain the best results, a return line should be run from the farthest end of the line, either to the tank or to an auxiliary chamber feeding into the suction side of the pump. Since this oil has once been through the strainer and is now free from extraneous matter it is better to return to the chamber on the suction side of the pump. With a 2-in. suction line, a 2-in. discharge, a 2-in. return line, and with 60 to 70 lb. pressure on the pump, enough oil will be circulated to feed 20 burners consuming from 1 to 3 bbl. of oil per hour.

With a good recycling system and with hot fuel oil, the same type of oil burner should function as efficiently with a heavy fuel oil as with a lighter grade. In case the burner projects into the furnace as when using preheated air, better results will be obtained when the oil and steam or oil and air are mixed outside of the furnace and the mixture then enters the furnace through a single pipe.

CLEAN SUPERHEATED steam and clean pure lubricating oil are the breath and blood of the steam turbine—destroy or contaminate either of these and a shutdown of the turbine is sure to follow.

Economical Use of Exhaust Steam

STUDY OF TYPES OF PRIME MOVERS NECESSARY FOR BEST RESULTS. BY A. F. SHEEHAN

IN MANY industrial plants such as paper mills, where steam for manufacturing purposes or process work is supplied by the exhaust of steam engines, it is generally considered that the plant is economical and consequently several important factors are usually overlooked. For instance, in medium sized mills, the prime mover for the paper machines is often of the single valve type having an initial steam pressure around 125 lb., 10 lb. back pressure, and with a water rate of at least 50 lb. per hp-hr. As long as all of the exhaust from this engine is needed in the driers, many engineers feel that the high water rate is of no consequence and they consider it an ideal installation.

But the power to drive paper machines is only a fraction of the total power required by the mill, as the heater room and rag cutters take several times as much power as the machine room, and, unfortunately, these two operations require practically no process steam. For this reason, the main engine must operate condensing, since it would exhaust several times as much steam as could be used if operated against 10 lb. back pressure.

CLOSE STUDY OF PRIME MOVERS NECESSARY

Here is where the defects must be studied closely. Consider a mill with an output of 35 t. of paper per day of 24 hr. The total power requirements will be about 1000 hp. and the machine room will require about 160 hp. and 840 hp. will be required on the main drive. Now, with a water rate of 50 lb. the small engines in the machine room will use (50×160) 8000 lb. of steam per hr. and usually about 2000 lb. of live steam are taken through a reducing valve to supplement the exhaust steam for the purpose of drying paper. The main engine is either a simple condensing unit with a water rate of 18 to 20 lb. of steam per hp-hr. or a compound condensing unit with a water rate of 14 to 15 lb. per hp. In a mill of 35 t. capacity, the compound engine is more often used than a single cylinder unit, so we will assume a compound unit with a water rate of 15 lb. at 125 lb. steam pressure and 26 in. vacuum. The steam consumption of the main engine will then be (15×840) 12,600 lb. per hr. and allowing 1000 lb. per hr. for the boiler feed pump and condenser pump, the total steam flow in a mill of this type is 8000 lb. for machine room engines, 2000 lb. live steam in the machine room, 12,600 lb. for the main engine and 1000 lb. for auxiliaries, giving a total of 23,600 lb. of steam per hr.

Now the steam used for process work is nearly constant and cannot be reduced to any great extent, so that this is not the main source of loss. But since the main engine exhausts 12,600 lb. of steam per hr. to a condenser, 85 per cent of this is wasted in the condensing water, therefore the heat equivalent of 85 per cent of 12,600 or 10,710 lb. of steam per hr., is wasted. Therefore, if the paper machine engines, with a water rate of 50 lb. per hp-hr., were replaced by economical engines with a water rate of 30 lb. per hp-hr. and all the steam used in the driers was passed through these engines (10,000 ÷ 30) 333 hp., or more than double the present amount could be developed with the process steam.

Since the requirements of the machine room are only 160 hp., the balance of 173 hp. could be applied to the main drive and the load on the main unit reduced by 173 hp. The condenser loss of the main engine would be reduced by (173 ÷ 840) 20.6 per cent. This would amount to a saving of 2595 lb. of steam per hr., or about 11 per cent of the total steam consumption of the mill. This gain could be made by generating more power from the process steam by an efficient engine and if this idea were carried still further, even greater gains might be possible.

NEW BOILERS AND ENGINES WOULD SHOW SAVINGS

Suppose, for instance, that new boilers and engines were installed and steam generated at 200 lb. pressure and high superheat and all process steam expanded from 200 lb. down to 10 lb. in uniflow engines. A non-condensing uniflow engine would probably have a water rate of 18 lb. under these conditions and 10,000 lb. of process steam would generate 555 hp., thus leaving only 445 hp. to be generated by the condensing engine. The condensing engine could attain a water rate as low as 11 lb. per hp. and would require only (11×445) 4895 lb. of steam per hr. The steam consumption of the condenser and the feed pumps would be reduced by at least half, as the condenser would have only 4895 lb. of steam to handle as compared with 12,600 formerly. The total steam flow would then be about as follows: 10,000 lb. of steam by the non-condensing engine, 4895 by the condensing unit, and 500 lb. by the condenser and feed pump, making a total of 15,395 lb. per hr.

Evidently, a reduction of [(23,600 — 15,395) ÷ 23,600] 34.77 per cent is possible and assuming an evaporation of 8 lb. and a coal cost of $7.00 per ton, the annual saving in fuel costs would be considerable. Since a mill of this type operates 7200 hr. in a year, the annual fuel cost is [(23,600×7200×7.00)÷(8×2000)] $74,340. If 34.77 per cent could be saved the actual saving would be $25,795 per year. This amount would pay all interest and fixed charges on a plant costing $184,250 at 14 per cent fixed charges.

But the new equipment would not cost over one-third of this amount. A 300-hp. water-tube boiler operated at 150 per cent rating would generate all the steam required and could be installed for $17,000, while two uniflow engines, one of 550 hp. and one of 450 hp. could be installed for $40,000. If the new equipment is installed in the old buildings the total cost will not exceed $62,000, thus making the net saving $17,115 per year after deducting fixed charges of 14 per cent on this investment.

STEAM EXTRACTION RECOMMENDED

Another type of installation might show even lower costs than uniflow engines. A compound engine of the Lentz type designed for steam extraction between cylinders could be used and in view of the high steam pressure, superheat and back pressure, the high pressure cylinder of this engine would show a lower water rate than a uniflow due to the fact that the terminal pressure would be much closer to the back pressure than in a uniflow unit. The high pressure cylinder could develop 1 hp-hr. on 16 lb. of steam and 625 hp. could be developed by passing the

10,000 lb. of process steam through this cylinder. This leaves 375 hp. to be developed.

The steam for the remaining 375 hp. could expand through both cylinders and the compound unit show a water rate of 10 lb. per hp. (These figures are not assumed as the writer was present at a test a few years ago where a 500-hp. compound engine showed a water rate of 9.95 lb. at 75 lb. steam pressure, 15 deg. superheat and 27 in. vacuum.) To develop 375 hp. would require 3750 lb. of steam and the total steam flow to the engine would be 13,750 lb. per hr.

Allowing 350 lb. for condenser and feed pump the steam consumption of the mill would be 14,100 lb. per hr., or 1295 lb. per hr. less than with uniflow engines. This is equivalent to 162 lb. of coal per hr., or $4082 per year ($162 \times 7200 \times 7.00 \div 2000$). Thus a total saving of $21,197 per yr. ($17,115+$4,082) is possible by efficient equipment. No allowance is made for the slight amount of coal necessary to generate steam at 200 lb. as compared with 125 lb. as this is more than offset by the economy of water-tube boilers with large furnace volume over old fire tube boilers with low settings and small furnace volume.

Tests at Hudson Plant Show Interesting Results

Effects of Bent Tube Boiler Design Marked by Draft and Temperature Conditions

RECENTLY, a series of tests on a stoker equipped V-type boiler was completed at the plant of the Hudson Motor Car Co. in Detroit, for the purpose of determining

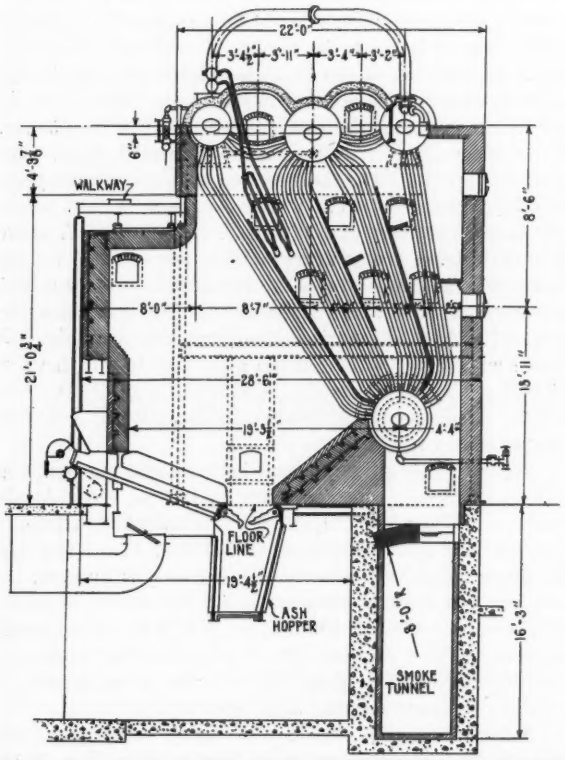


FIG. 1. FOUR PASS, V-TYPE HEINE BOILER WITH UNDERFEED STOKER

the merits of the bent tube boiler design. These tests were conducted by R. L. Spencer and W. C. Steinheimer of the engineering department of the Heine Boiler Co. The unit on which the test was made consisted of the following equipment:

Boiler—Heine, V-type, four pass, fifteen tubes deep, 20 ft. center to center of drums, 6285 sq. ft. heating surface. Boiler designed for 180 lb. pressure. Operating pressure 150 lb.

Superheater—Elesco, double loop, located at top of second pass, 570 sq. ft. heating surface. Superheat 150 deg.

Stoker—Westinghouse underfeed, six retort, 107.8 sq. ft. projected grate area.

Furnace—12 ft. wide, 2460 cu. ft. volume.

Stack—Radial brick, 12 ft. 6 in. diam., 175 ft. above boiler room floor, serving four boilers.

Four efficiency tests were run, these being at 99 per cent, 147 per cent, 183 per cent and 228 per cent of rating. The first two tests were of 24 hr. duration, and the other two runs of 12 hr. duration. In addition, three short runs at low percentages of CO_2 namely: 7.4 per cent, 9.4 per cent, and 12.3 per cent, were run. The lower CO_2 tests were of 4 hr. duration only and the efficiency was calculated from a heat balance.

The tests represent actual operating conditions as nearly as it was possible to make them. The boiler was

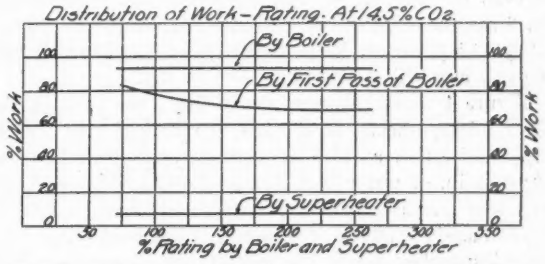


FIG. 2. FIRST PASS DOES 78 PER CENT OF THE WORK

thoroughly cleaned before the series was started. Feed water was measured in calibrated tanks at a temperature of about 70 deg., so that no correction for temperature of the water was necessary.

It should be borne in mind that the stack capacity limited the ratings that could be obtained. Using all the available draft, with the damper wide open and carrying 15.1 per cent CO_2 the highest rating obtained was at 228 per cent. This was in no way due to an excessive draft loss through the boiler, as the test data shows that the draft loss was quite low for a boiler of this type.

Crushed Kentucky coal of the following proximate analysis was used:

Moisture	4.7 per cent
Volatile matter, dry basis	35.6 per cent
Fixed carbon, dry basis	55.6 per cent
Ash, dry basis	8.8 per cent
Heating value per lb., as fired	12,905 B.t.u.

Figure 2 shows how the work was distributed in the different passes of the boiler. It should be particularly noted that the work done by the first pass of the boiler, that is, the first three tubes, amounts to approximately 78

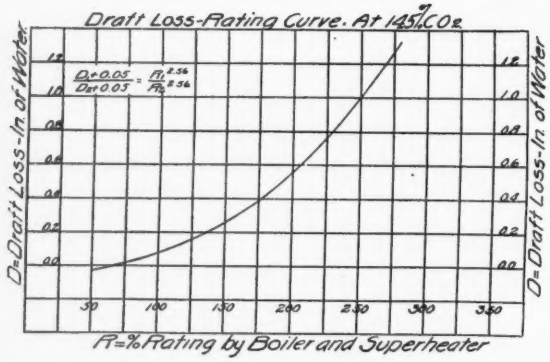


FIG. 3. DRAFT LOSS THROUGH SETTING COMPARED WITH PER CENT OF BOILER RATING

per cent at rating, and decreases to approximately 68 per cent at 250 per cent of rating. All the steam formed in these first three tubes passes to the front drum, thence through the steam connectors into the middle drum and finally through another set of connectors into the rear drum. On account of the length of the steam travel this 70 per cent of the steam generated in the first pass has a fine opportunity to drop its entrained moisture.

Draft loss through boiler and superheater plotted against rating is shown in Fig. 3. This quantity amounts to 0.08 in. of water at 100 per cent of rating and increases in a curve whose exponent is 2.56 to 1.00 in. of water at 250 per cent of rating. This draft loss is considered quite low even for a boiler of this type. The curves shown in Fig. 3 are for a boiler operated at a high CO_2 of approximately 14.5 per cent. When the CO_2 is allowed to decrease, the draft loss will increase as shown in Fig. 3.

Figure 4 shows the variation of draft loss through the boiler and superheater at 150 deg. of rating plotted against CO_2. Notice that at 14.5 per cent CO_2 the draft loss was only 0.25 in. of water, but that as the CO_2 decreased, the draft loss increases in a curve whose exponent is 2.00 to approximately 0.76 in. of water at 8 per cent CO_2. This curve illustrates clearly the importance of carrying high CO_2 if high ratings are to be expected from the boiler with limited stack or fan capacity. This is because high CO_2 means low excess air, with a consequent reduction in the total quantity of gas to be handled at a definite boiler rating. As a result, more pounds of coal can be burned with the same draft loss, or this is another way of saying that the capacity of the stack has been increased. As

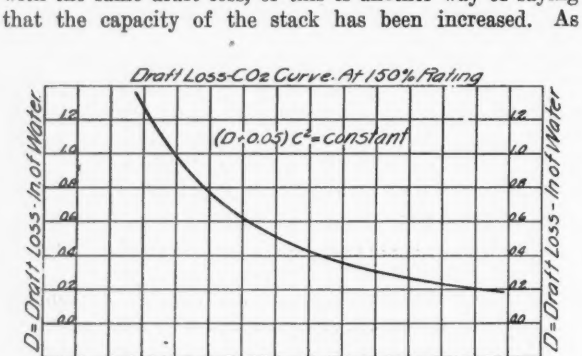


FIG. 4. DRAFT LOSS WITH GIVEN LOAD COMPARED WITH VARIATION IN CO_2

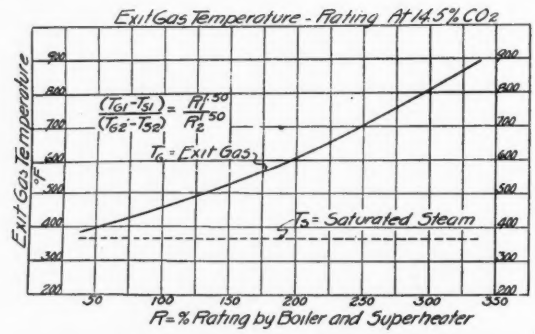

Exit Gas Temperature - Rating At 14.5% CO2
Exit Gas Temperature °F
Tg = Exit Gas
Ts = Saturated Steam
R=% Rating by Boiler and Superheater

FIG. 5. FLUE GAS TEMPERATURE COMPARED WITH BOILER RATING AT BEST CO_2 CONDITIONS

noted at the beginning of this article, limited stack capacity prevented higher ratings being obtained in this test.

Flue Gas Temperature Low for Type Boiler

Exit gas temperature at 14.5 per cent CO_2, plotted against rating is shown in Fig. 5. The dotted line curve of the temperature of the saturated steam or water in the boiler is shown for the sake of reference. Notice that at 100 per cent rating the exit gas temperature is 455 deg. F., or approximately 90 deg. above saturated steam temperature. As the rating is increased the exit gas temperature increases in a curve whose exponent is 1.50 up to exit gas temperature of 700 deg. F., or 345 deg. F. above saturated steam temperature at 250 per cent of rating. These exit gas temperatures are remarkably low for a bent tube type of boiler, and indicate that the boiler may be operated at high efficiencies. The curve shown in Fig. 5 is drawn with the CO_2 held at the approximately high value of 14.5 per cent. If the CO_2 is allowed to decrease, there will be a corresponding increase in the exit gas temperature as shown in Fig. 6.

Figure 6 shows the relations between exit gas temperature and CO_2 at a constant rating of 150 per cent. At the value of 14.5 per cent CO_2 carried throughout the efficiency test, the exit gas temperature is 530 deg. F., or 165 deg. F. above steam temperature. As the CO_2 is lowered, the exit gas temperature increases in a curve whose exponent is 0.75 up to a value of 600 deg. F., or 245 deg. above steam temperature at 8 per cent CO_2. The curve clearly indicates the importance of a high CO_2 in order to maintain low exit gas temperature and high economy.

Relation between efficiency of boiler, superheater, and grate plotted against rating is illustrated by Fig. 7. At

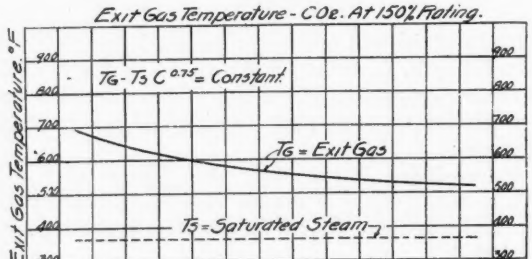

Exit Gas Temperature - CO2. At 150% Rating.
Tg - Ts C^0.75 = Constant.
Tg = Exit Gas
Ts = Saturated Steam
Exit Gas Temperature °F
C = CO2 In Flue Gas. %

FIG. 6. FLUE GAS TEMPERATURE WITH GIVEN LOAD COMPARED WITH VARIATION IN CO_2

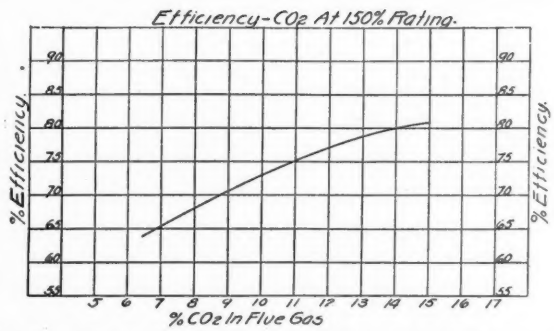


FIG. 7. OVERALL EFFICIENCY COMPARED WITH BOILER RATING

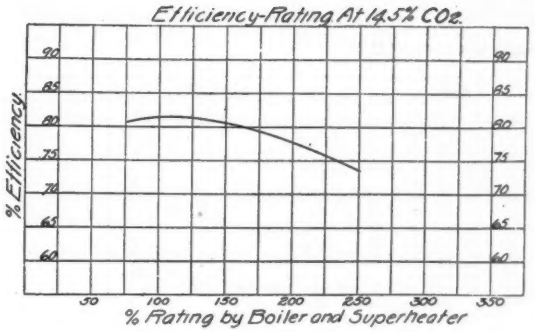


FIG. 8. OVERALL EFFICIENCY WITH GIVEN LOAD COMPARED WITH VARIATION IN CO_2

100 per cent of rating the efficiency is approximately 81.5 per cent. This efficiency remains constant for a short distance, then as the rating is increased, drops off more and more rapidly until at 250 per cent rating the efficiency is approximately 73.2 per cent. These efficiencies are remarkably high for a boiler of this type. In order to maintain this high efficiency, a high and uniform CO_2 must be maintained. When the CO_2 is allowed to decrease, there will be a corresponding decrease in efficiency as shown in Fig. 8.

These high efficiencies are all the more pleasing when it is remembered that the draft losses are as low as shown in Fig. 3. This speaks well for the design of the boiler and for the simplicity and effectiveness of baffling. Tubes have been so designed that there are no gas pockets and empty spaces for the gases to traverse in passing through the boiler and the gases are closely confined to the tube bank. Constant gas velocity has been secured without the use of elaborate and intricate baffle forms. The gases are not required to pass through a maze of tortuous paths which result in a high draft loss. The simplicity of baffling also makes for low maintenance cost and reduces the time required to make replacements.

Figure 8 shows the relations between CO_2 and efficiency at a constant rating of 150 per cent. At the CO_2 of 14.5 per cent, carried throughout the efficiency test, the efficiency is 81.0 at 150 per cent of rating. As the CO_2 is decreased the efficiency decreases down to a value of approximately 66 per cent and 8 per cent CO_2.

The success of the tests is due partly to the excellent performance of the stoker with which the operators were able to maintain a CO_2 of 14.5 per cent constantly throughout the test without carbon monoxide being detected. The combustible in the ash throughout the test varied from approximately 20 per cent to 26 per cent. This ashpit loss might be considered a little high at the lower ratings, but is acceptable at the higher ratings.

Plant Records Tell Where the Coal Dollars Go

TYPICAL EXAMPLES OF PLANT RECORDS FROM VARIOUS INDUSTRIES SHOW HOW ANALYSIS OF POWER COSTS MAY BE MADE*

OPERATING MEN throughout the country become more fully aware of the necessity of knowing what their power plants are doing and also of the imperative need of having reliable and permanent records kept of the performance of their plants. As competition increases in the industrial field, the power plant department is bound to be scrutinized more carefully, and, as fuel advances in price, industrial executives will seek further economies in its use. With increased competition confronting the industries selling their product, there is bound to come increased competition in the field of the operating engineer. The wide awake men who know what their plants are doing will most certainly be the men in greatest demand. The economic relationship of heat and power is not as well understood in the industrial field as it should be and, as more careful analyses of power plant costs are made, more plants and better plants will come. In numerous plants, however, there are no records available by which the facts can be presented to the owner or employer who is paying the bills.

Few industrial executives are technically trained and they have, accordingly, fought shy of their power plants, notwithstanding that these departments are indispensable. In the absence of a businesslike interest in the power plant on the part of the executive, operating engineers, as a class, have become more or less isolated from the rest of the organization. Operating engineers have lost prestige because they have taken little interest in the industry as a whole and have been contented to remain in the rut of simply running the power plant.

But what has the power plant earned? Has it paid its way and is it highly profitable? Or is it just a necessity which is tolerated because it has to be?

PLANT SIZE NOT NECESSARILY AN INDICATION OF LOW COST

Some businesses can be made profitable only when conducted on an enormous scale but the matter of producing and distributing electrical power can be overdone and it is not beyond the range of possibility that the centralization of power may soon reach a point where costs will advance instead of decrease. Small power plants are now beginning to receive much more attention and, as costs are more thoroughly analyzed, the advantages of small power plants will become much more pronounced. All the advantages of electric power drive can be obtained by generating electricity in a small plant that are available with purchased power and, in many instances, at greatly reduced costs.

*Abstract of report of Power Plant Costs Committee of N.A.S.E., presented at 43rd annual N.A.S.E. convention, St. Paul, Minn., Aug. 31 to Sept. 4, 1925.

TABLE I. COMPARATIVE POWER COSTS OF TWO HOTELS, A PURCHASING POWER AND B OPERATING ITS OWN PLANT

Items	Case "A"	Case "B"
Contents of building - cu. ft.	1,000,000	1,250,000
Electricity used - kw.-hr.	64,300	149,060
Tons of coal consumed	1,200	2,045
Total number of men employed to operate plant	3	4
Total annual cost of heat, light, power and refrigeration	$21,373.00	$16,724.00
Cost per kw.-hr., including heat, and steam for all purposes	.33	.11
Cost per yr. per 1,000 cu. ft. of space	21.37	13.40
Pounds of coal consumed per kw.-hr. used, including heat and steam	37.3	27.7

Power plants still have to be operated. Knowledge of their performance and permanent records of costs are just as much the duty of a first class operating engineer as knowledge of plant maintenance and safety in its operation.

Because John Smith purchases power and says it is cheaper than he can make it is no reason why Bill Jones could profitably do the same thing. Each is an individual case and can be settled only on the most economical basis by a study of the conditions prevailing in that case—not by doing what some of your neighbors are doing. A liberal interchange of cost records from plants in similar lines of industry should be productive of much valuable information and should also lead to lower costs of operating. If we get the facts there are no mysteries about the accomplishments to be attained but the difficult job seems to be, in many cases, to establish the facts.

Capital Charges with Purchased Electric Power

It is frequently argued that when power is purchased there are no carrying charges on capital investment in power plants. This is a line of reasoning entirely unsound in principle, because any power which is sold from a power producing plant must be sold on a basis that will yield a profit on the investment required to produce it. If it were otherwise, the enterprise would be doomed to failure. Most of the rate schedules of the power distributing companies of the country are now constructed so that the capital charges, commonly called demand charges, are shown separate in the power bill from the running or power making charges. The investment in a large central station property is a large item in that business and, due to the large investment involved, the central station cannot compete with many small power plants where steam boilers have to be installed for purposes other than power production.

TABLE II. POWER COSTS FROM A SHOE FACTORY

Items	Item Cost	Per Cent of Total Cost
(1) Coal, 1767 tons	$7686.00	53
(2) Operating labor 3 men (night man acts as night watchman also)	5424.00	37.5
(3) Repairs and Maintenance	526.00	
(4) Lubricants	350.00	
(5) Miscellaneous supplies	300.00	9.5
(6) Water for plant	200.00	
13 months total	$14,486.00	100

Many people think only of the large power station and forget all about the distributing system which is necessary in the delivery of the power. The investment in the distributing property of the large power companies represents more capital than is involved in the power producing plant.

The investment in the large power companies' properties will run about like this:

Transmission and distributing system.....47 per cent
Generating plant .....33 per cent
Miscellaneous general and intangible property..20 per cent

Total investment .....100 per cent

From these figures it will be seen that the large power station represents only one-third of the total investment required to get power to the customers' meters.

Hotels Offer Excellent Opportunities

The hotel industry ranks well up at the top of the list of big business enterprises, yet in the same city we will find one hotel operating its own electric generating plant and a few blocks away we will find another hotel, of the same general type and rendering the same class of service, purchasing its power. Each manager and each engineer claims he is saving money the way he is operating, yet one does diametrically the opposite to the other. Both cannot be right and the fault lies in not knowing what their costs are in one case or the other.

There is probably no industry using a similar amount of power which offers better opportunities for low production costs of heat and power than the modern hotel of fair size. Yet in this industry one can find power plants where records are in a deplorable condition, if not entirely missing. But hotels are no different in this respect from other lines of industry.

To illustrate the possibilities, we give in Table I the power costs in two small hotels. One generates all its elec-

TABLE III. COMPARISON OF POWER COSTS OF KNITTING MILL WITH COSTS OF PURCHASED POWER

NATIONAL KNITTING COMPANY MILWAUKEE, WISCONSIN. L.H. STARK, CHIEF ENGINEER.

POWER PLANT REPORT 1924.

Month	Generated Current, K.W. Hrs.	Purchased Current, K.W. Hrs.	Total Current, K.W. Hrs.	Generated Steam, Lbs.	Coal Used, Lbs.	Cost of Coal	Operating Expense: Salaries	Supplies	Repairs & Insurance	Water	Dep. Mach. & Equipment	Overhead on Bldgs.	Factory Overhead	Total Expense	Commercial Valuation of Services: Purchased Energy	Elec. Energy	Steam at low pressure rates	% of Factory O/H	Labor	Total
JAN.	35590	20740	74830	8847240	1020000	$ 321.06	$ 895.95	$ 97.33		$ 26.32	$ 61.543	$ 49.42	$ 586.20	$ 5481.26	$ 670.88	$ 1522.31	$ 5750.73	$ 293.10	$ 290.00	$ 7856.18
FEB.	48570	21610	70182	6814190	903500	207.694	946.40	57.69	Repairs	29.75	61.543	49.42	504.53	4298.16	759.11	1417.66	4429.22	250.26	290.00	6387.16
MAR	41280	17329	58509	5960240	686000	214.276	1208.01	58.36	Fire	23.52	61.543	49.42	474.00	4570.96	682.40	1179.70	3876.00	237.00	355.00	5645.70
APR	48260	9244	57504	5684700	665000	152.345	959.17	82.1	York 70630	36.76	725.50	57.00	606.78	3916.67	478.68	1371.63	3668.60	303.39	290.00	5613.62
MAY	51640	6222	57862	5653980	685200	171.736	1193.62	48.14		36.76	660.40	45.60	440.69	4147.01	243.00	1464.60	3675.10	220.54	350.00	5710.04
JUNE	53430	6962	60392	4909725	567500	127.676	963.39	63.46	Insurance	36.55	660.40	45.60	438.81	3471.82	259.39	1513.82	3126.50	219.40	290.00	5149.72
JULY	40790	7878	48668	3329370	512336	135.599	969.22	53.05	$ 385.80	37.64	$ 25.50	57.00	570.82	3869.00	284.18	1164.21	2163.85	285.61	290.00	5390.39
AUG	42740	7900	50640	4226675	556716	110.864	998.16	50.20		38.09	660.40	45.60	416.46	3520.98	282.43	1221.21	2747.53	217.47	290.00	4467.21
SEP	39790	5212	45002	3547135	543000	132.566	962.79	48.30		23.58	825.50	45.60	420.46	3486.79	206.71	1135.01	2308.35	210.23	290.00	3943.59
OCT.	38680	5421	44101	3855850	667750	123.368	1006.19	57.29		39.82	660.40	57.00	468.20	3684.68	211.04	1092.38	2586.46	234.10	290.00	4172.88
NOV.	43660	7008	58668	4608100	651750	162.064	819.52	49.39		40.75	660.40	45.60	389.00	3625.40	262.35	1391.65	2995.20	194.56	290.00	4871.35
DEC.	51960	6723	56683	5930110	814750	189.419	878.58	49.38		40.39	660.40	45.60	796.00	4310.44	203.07	1673.40	3834.50	398.00	290.00	5711.50
TOTAL	539440	120251	679691	63223365	8273586	2043.194	11823.00	623.26	1091.90	408.08	8185.19	592.86	6106.43	49,275.31	4573.46	15947.58	41,099.98	3063.20	3605.00	63,665.74

Steam corrected for high pressure used $ 539.67

Total Value of Steam $ 49,638.05

tricity and furnishes all steam for laundry, kitchen, baths and swimming pool. The other buys all its electricity and operates a boiler plant for its various steam needs, including laundry, kitchen, baths, and the like.

Case "A" operates boilers for heating and purchases all electricity. Case "B" supplies all services of heat, light and power and refrigeration from its own power plant. In case "B" the building is 25 per cent larger and its plant generates nearly 2½ times as much electricity as case "A" buys. Yet "B's" operating expenses for heat, light, power and steam are 22 per cent less.

In most hotels the size of the boiler plant (whether high pressure or low pressure boilers are used) is fixed by the demands for heat and steam for laundry and kitchen. If electricity is purchased the size or the cost of the necessary boiler plant is not, as a rule, changed at all.

Figures from a Shoe Factory

We are indebted to the Nunn Bush and Weldon Shoe Co. of Milwaukee, Wis., for the figures shown in Table II from their power plant for the year ending with May, 1925. This factory produces a line of fine shoes for men and boys.

Uses for steam outside of power and heating purposes are small, so that this plant presents an interesting example of how cheaply a non-condensing steam plant can produce its power when using the exhaust steam for heating the building. The factory buildings have a volume of approximately 1,750,000 cu. ft. of space, which has to be heated about 7.5 to 8 mo. out of the year. Exhaust steam is used for heating and when no heat is required the exhaust goes to atmosphere. At times of extreme low temperatures all the exhaust is not sufficient to keep the buildings warm and during such periods the deficit is made up with high pressure steam through a reducing valve. For the 12-mo. period, 1767 t. of coal were burned and 413,830 kw-hr. generated. If this electric power had been purchased at 3 cents a kw-hr. it would have cost 66 per cent more than the entire coal bill.

Power Costs of a Textile Mill

The National Knitting Co. of Milwaukee turns out a diversified line of knitted woolen goods such as bathing suits, sweaters and gloves. Table III shows costs from this plant for 1924. A large dye-house is operated which requires large quantities of hot water; this absorbs a large amount of exhaust steam. During a heating season of about eight months, 2,477,244 cu. ft. of space is heated by exhaust steam.

If the steam and electric services this plant turns out had been purchased at the prevailing rates for these services, the costs would have been 47 per cent more than the operating and maintenance expenses of the power plant.

Since publication some time ago of the saving made by the R. H. Macy & Co. department store in New York City, from operating its own power plant, there have been a number of requests for further details as to show how this saving was arrived at. Table IV shows some of these details.

Salaries referred to in this report are those of employes that could be dispensed with if the plant were shut down. The item "Steam supplied to ventilation" is that used to heat the air for ventilating purposes during the heating season. In addition to this, steam is also used to heat the building by direct radiation. The figures do not include any credit for the economizer in the incinerator, which was put into operation a few months ago and has resulted in a fuel saving of about 500 gal. of oil a day, which at the present rate is equivalent to about $7500 a year.

It is interesting to note in this case that, if steam and electricity had been purchased, the cost of these services would have been 67 per cent more than the operating expenses of the plant.

If the difference between what the services of steam and electricity would have cost if purchased and what it cost to operate the power plant were capitalized at 25 per cent, it would amount to something over $430,000. In other words, the plant earns 25 per cent on $430,000 or 20 per cent on $540,000 per year.

TABLE IV. POWER PLANT RECORDS FROM LARGE DEPARTMENT STORE, SHOWING SAVING BY OPERATING OWN PLANT

Total fuel oil burned (1924)	2,870,373 gal.
Total kw.-hr. produced (1924)	7,535,933 kw.-hr
Steam supplied to heating	40,000,000 lb.
Steam supplied to ventilation	25,000,000 lb.
Steam supplied to hot-water heating	13,000,000 lb.
Steam supplied to feed-water-heating (bldg.)	7,000,000 lb.
Steam supplied to kitchen and laundry	13,000,000 lb.
Steam supplied to miscellaneous units	10,000,000 lb.
Cost of fuel oil burned	$121,879.25
Cost of lubricants, wastes, etc.	6,281.00
Cost of repairs and expenditures	7,162.49
Cost of rental charges for floor space	11,253.15
Cost of salaries of generating plant	15,960.00
Macy's power plant total cost of operation	162,534.99
Commercial values of service:	
75,000 kw.-hr. at 5¢ per kw.-hr.	$ 3,750.00
100,000 kw.-hr. at 4¢ per kw.-hr.	4,000.00
150,000 kw.-hr. at 3¢ per kw.-hr.	4,500.00
775,000 kw.-hr. at 2½¢ per kw.-hr.	19,375.00
6,435,933 kw.-hr. at 2¢ per kw.-hr.	128,718.66
Coal adjustment at $0.0032 per kw.-hr.	24,114.98
Total power cost if power were purchased	184,458.64
40,000,000 lb. steam at 80¢ per 1,000 lb.	$ 32,000.00
25,000,000 lb. steam at 80¢ per 1,000 lb.	20,000.00
13,000,000 lb. steam at 80¢ per 1,000 lb.	10,400.00
7,000,000 lb. steam at 80¢ per 1,000 lb.	5,600.00
13,000,000 lb. steam at 80¢ per 1,000 lb.	10,400.00
10,000,000 lb. steam at 80¢ per 1,000 lb.	8,000.00
Total cost of steam if purchased	86,400.00
Total cost of purchased power and steam	270,858.64
Macy's power plant cost of same service	162,534.99
Total power plant saving over purchased service	108,323.65

Plants having figures of actual performance have little trouble in being retained in service when the economic conditions are favorable for private plants.

Electric Plant Survey of Germany

Germany now has 3380 electric plants in operation according to a recent issue of the "Verzeichnis der deutschen Elektrizitaetswerke" published in Berlin. This includes all generating and consuming plants. Of the generating stations 190 have capacities of over 5000 kw.

The largest station is the Goldenberg-Werk in Knapsack near Koeln, which has a capacity of 302,000 kw. It is also the largest peat-burning steam station in the world. The next largest peat-burning steam stations are Zschornewitz, 168,000 kw., and Trattendorf, 66,000 kw., which deliver most of their energy to Berlin over 100,000-v. lines.

The largest hydro-electric plant is near Kochel, producing 117,000 kw. Several other large hydro-electric stations are being planned or are under construction. Those in Baden will have a combined capacity of 260,000 kw.

The directory lists all German electrified cities and villages with a population above 1000, including the kind of current and voltage of all transmission lines.

ELECTRICAL MACHINERY FOR LIGHT AND POWER

Trouble Shooting in D. C. Motors and Generators

DESCRIPTIONS OF METHODS OF MAKING TESTS REQUIRING THE USE OF ONLY A FEW INSTRUMENTS. BY CHARLES G. GREEN*

IN MANY CASES it is necessary for the man on the job to make tests and locate faults in motors and quite frequently in generators. In case of excessive sparking at

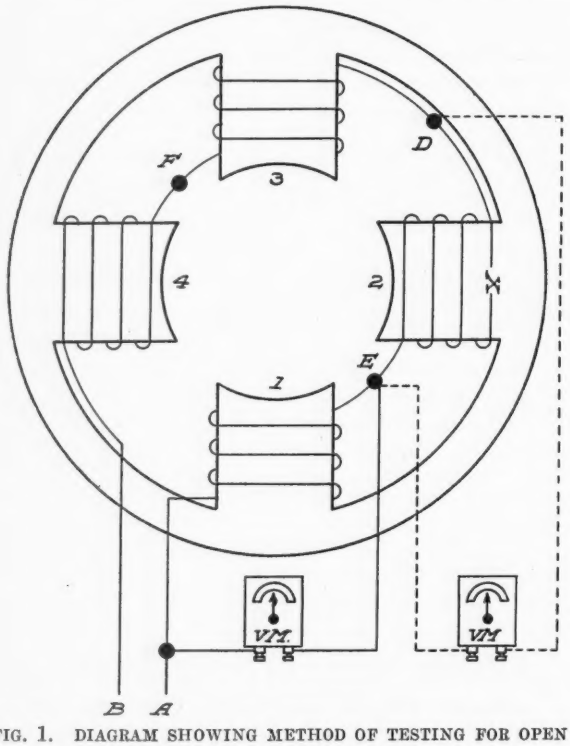


FIG. 1. DIAGRAM SHOWING METHOD OF TESTING FOR OPEN CIRCUITED FIELD COILS

the commutator or not enough torque to carry the load it has often happened that the trouble shooter has reported armature trouble, probably on some large motor where it required the "sailor gang" to get the armature to the electric shop and then that the armature men have found that the armature was O.K. A case of this kind is most likely to put a shadow on the trouble shooter who was responsible for this wasted time and expense.

Often it has happened that when a trouble man was sent on a job, if he knew his stuff, he would take a few minutes to locate and temporarily, if not permanently, correct the trouble, thus saving a shut down, which might mean a heavy expense to the plant or company. And in some of these cases by not knowing his work properly, he has been the cause of great expense.

The man who is in charge of a motor route, or perhaps all the motors in a small plant, should, in every case, learn some simple, sure methods of locating trouble which, if he understands the theory and action of motors, controllers and control apparatus, will set him aside from the average trouble shooter and, if he keeps studying in his spare time to learn new and up-to-date methods so that he can do his work just a little better and quicker than others and with less shut downs, he will in time, become recognized by his superiors and given a chance for advancement.

One thing a man must guard against when he is trying to study or learn new methods, is not to become a "know-it-all," trying to show someone up, or trying to tell the boss how much he knows. He must be a good listener and willing to be shown. In some places (it's a shame to say it, but it is true) it is not what a man knows that gets him a better job, but it's whom he knows. If this were not the case, many large expense and upkeep bills would be cut in half. It's getting to be a fact, if a man belongs to the same lodge or goes to the same church as the chief engineer or chief electrician, that he is given a job where he knows about enough about it to carry him over a holiday, if he were credited according to his ability and not his "drag" with the boss. In the face of all this, however, and in the face of any other hardships that confront a man in his climb to success, there is no man, who has any ambition at all, will say it is no use to try for anything better. Many bosses, although they never tell you or show it outwardly, are still watching for a man who will be able to take a better job or whom they can trust and bank on in case of emergency. With this in mind it is well and wise for any man who wishes to get out of the worn "rut" always to be on the look out for new, simple ways of doing his work more efficiently. Just try it and see if you don't get interested and enjoy it, whether or not it brings in immediate returns.

Following are a few simple tests which require little equipment. Along with these it is well to read some good technical periodical and practical books, or study in some way to get out of the "rut," and habit of drifting along and passing the buck.

Open circuit in a field coil will cause a motor to race when not loaded and to have poor torque, if loaded, along with sparking and burning at the brushes. A heavy armature current will also result from a weak or open field and,

*Instructor in motor department, Coyne Electrical School.

if not found in time, will mean the expense of rewinding the armature. To find an open-circuited field coil is a simple job, once it is decided that the field is the cause of the trouble. By connecting all the coils in series as they generally are and connecting to supply lines as at A and B, Fig. 1, then connecting a voltmeter first across one coil, A to E, and then the next, E to D, and so on, we find the open coil when the voltmeter indicates almost the full line voltage when bridging the open circuit at X; the good coils 1, 3 and 4 will give zero reading on the meter. It is also possible to leave one side of the meter connected to A and touch the other connection successively to E, D, etc.; no deflection will be obtained until the open coil is bridged. A common test lamp can also be used, if preferred to the voltmeter.

In some rare cases, two or more coils may be open and in this case we would get zero reading on all coils. The

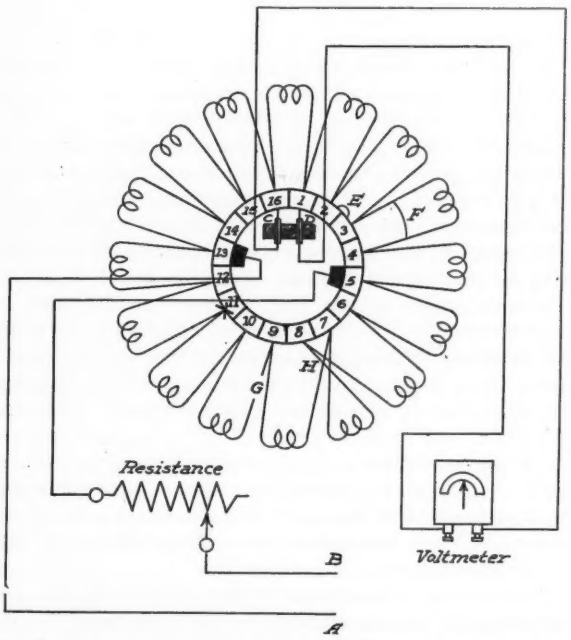


FIG. 2. WIRING DIAGRAM OF ARMATURE CONNECTIONS INDICATING METHODS OF TESTING FOR OPENS, SHORTS, WRONG CONNECTIONS AND GROUNDS

best way, in this case, is to use the voltmeter as in Fig. 1 and, each time we move the voltmeter, short all the other coils in succession with a wire or, if the voltage is high and you feel unsafe by shorting any coil out, it may be wise to use a test lamp or high resistance. If a lamp is used, do not expect the lamp to light when the two open coils are bridged, one with voltmeter and one with lamp. You will get only register on the meter of the voltage or almost the voltage of the line.

Shorted Field Coil

To find a shorted field coil, proceed as just described for finding one open field coil but it is better to limit the current through the field coils to a safe amount. In this case, as in Fig. 1, if all the coils are in good condition, the voltage drop as indicated on the voltmeter when connected across the different coils as A to E or E to D should be equal to the voltage of the line divided by the number of coils in series. If, however, one of these coils was shorted the voltage drop across the defective coil, as shown by the voltmeter will be much less than that across any other coil, and the other coils will have a higher voltage drop than the line voltage divided by the number of field coils in series.

Grounded Field Coil

Grounding of a field coil can be found by applying a voltage to the terminals of the entire field with all coils in series. Then connect one lead of a voltmeter to the frame and touch the other lead successively to exposed parts of the field circuit, such as connections to the various coils. The nearer to the ground the exploring lead is touched, the less will be the deflection.

In winding an armature, it is always advisable to test the winding for grounds and short circuits before the coils are connected to the commutator. If there are no shorts or grounds which show up on a test lamp or meter, the armature should be given an insulation break-down test. This can be done by connecting the series of coils to one terminal of a high-voltage transformer, with the other terminal of the transformer connected to the shaft of the armature. The alternating-current pressure which should be applied for breakdown tests on completed machines according to recommendations of the American Institute of Electrical Engineers, is given in the following table.

Rated Voltage of Device Under Test	Capacity	Testing Voltage
Not exceeding 400 v.	Under 10 kw.	1,000 v.
Not exceeding 400 v.	10 kw. and over	1,500 v.
Over 400 and less than 800.	Under 10 kw.	1,500 v.
Over 400 and less than 800.	10 kw. and over	2,000 v.
Over 800 and less than 1,200	Any	3,500 v.
Over 1,200 and less than 2,500	Any	5,000 v.
Over 2,500 and less than 10,000	Any	Double the rated voltage.
Over 10,000 and less than 20,000	Any	10,000 v. above rated voltage.
20,000 and over	Any	50% above rated voltage.
Synchronous motor fields and fields of rotary converters started from the a.c. side		5,000 v.

Testing for Faults in Finished Armatures

Shown in Fig. 2 is a test which will enable the workman to locate open circuits, short circuits, wrong connections and grounded coils and, if need be, grounded commutator segments. With the armature either mounted in a suitable rack, or left in the motor frame if need be, we can allow a steady current, controlled by the adjustable resistance in series with the armature, to be sent through the armature by way of terminals A, B. Now fix the leads of a low-reading voltmeter stationary to a small block of wood, or, by some other method, hold them just far enough apart to touch adjacent segments as shown at C, D. If there are no defects in the armature, the voltmeter reading will be almost the same for each pair of adjacent segments. If the reading on each pair is very low we can increase the current through the armature, until the reading is large enough to give accuracy. Sometimes it is necessary to try several pairs of segments in order that a standard average reading may be obtained. If there are shorted segments as at E or a shorted coil as f, we shall have almost no deflection on the voltmeter when pairs 2-3 or 3-4 are touched.

Poor connection between a segment and the two coil leads joining to it will cause a larger deflection than the average when the pair of segments touched contains the one with the poor connection to it as 11-12 or 10-11 where

X indicates a loose or poor connection to 11. An open circuit in any coil, as at g, will prevent any flow of current through that entire half of the armature, and when this is bridged as at 9-10 the full testing voltage of the line will be impressed on the meter and may do damage to it if it is a low-reading meter. In this case, it is best to use a test lamp, when it is found that there are no readings on a few pairs of segments in succession, as it may save damage to the meter. Crossed leads as at H will cause a double reading at 6-7 and also at 8-9 with a reversed normal reading at 7-8.

These tests as given will be good on simple ring or drum lap windings. For drum wave windings, however, if you touch the voltmeter leads from segment to adjacent segment you will be measuring two coils instead of one, if it is a 4-pole machine, and three coils if it is a 6-pole machine.

If it is a duplex winding, the test for lap or wave will be to touch voltmeter leads from 1-3, 2-4, etc.; for triplex winding test, from 1-4, 2-5, 3-6, etc.

In most cases it will be found that the diagram of Fig. 2 will serve the purpose, as the majority of armatures are of ring or loop-wound type. In case of a grounded coil, it can be found within two coils; then disconnect these from the coil end where the lowest reading is indicated, which can be located by grounding one meter lead and finding the segment and test each separately.

Selection and Maintenance of Circuit Breakers

AN ANALYSIS OF THE FORCES ACTING IN AN OIL CIRCUIT BREAKER TOGETHER WITH A DISCUSSION OF THE FUNDAMENTALS OF CONSTRUCTION

OIL CIRCUIT BREAKERS and associated control equipment for use in industrial service should not only possess the inherent design features which adapt them to the general requirements of central station service, but

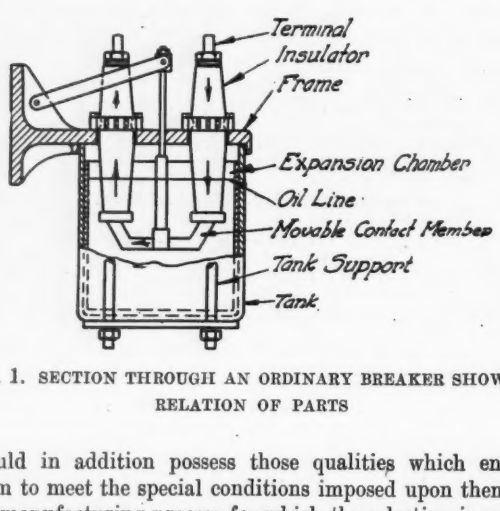


FIG. 1. SECTION THROUGH AN ORDINARY BREAKER SHOWING RELATION OF PARTS

should in addition possess those qualities which enable them to meet the special conditions imposed upon them by the manufacturing process for which the selection is made. In the cement and flour industry, for example, special constructional features are necessary in many instances in order to keep the working parts free from dust. The chemical industry often requires special treatment of materials in order to enable them to withstand the effect of destructive fumes. So also in the iron and steel industry, special requirements are imposed, particularly in view of the conducting dust deposited on insulating surfaces.

With regard to the selection of oil circuit breakers and their maintenance for iron and steel mill service, George A. Burnham of the engineering department of the Condit Electrical Manufacturing Co., delivered an unusually interesting paper upon the subject at the Twentieth Annual Convention of the Association of Iron and Steel Electrical Engineers, held at Philadelphia, Pa., September 14 to 19. Mr. Burnham discussed the entire situation in considerable detail and while in this abstract it will be impossible to give a complete report of his paper, we shall endeavor to bring out the most important points, particularly those regarding circuit breaker selection and maintenance in which the power plant man is interested.

In the selection of an oil circuit breaker for any purpose, said Mr. Burnham, it is first necessary to make a study of the system on which the proposed installation is to be made for the purpose of determining its electrical characteristics. These include the normal working voltage of the system, the continuous carrying capacity of the circuit in question and the transient current and voltage conditions under various circuit combinations. From this may be determined the interrupting requirements, the momentary carrying capacity and the insulation specifications.

Consideration should then be given to the work or "operating duty" of the breaker—for instance, the number of circuit interruptions under normal working conditions, which is determined by the processes of the industry; the circuit interruptions and reclosures under abnormal conditions such as short circuits.

Thus far we have given consideration to the factors which determine the physical dimensions of the oil circuit breaker unit and at this point it is important to study the different design features of the breakers offered by electrical manufacturers.

In making a comparison of the design features, it is interesting to consider the destructive forces acting on the breaker parts such as the frame or top, tank fastenings and insulators. Figure 1 shows the relation of parts in a breaker of ordinary construction. The destructive forces may be divided into three classes, mechanical, chemical and electromagnetic.

MECHANICAL FORCES

At the instant the contacts in a circuit breaker part, an electric arc is sprung which displaces the oil. The rate of expansion and volume of gases generated depends to a large extent on the energy to be interrupted, the speed of circuit interruption; cooling effect of the oil and the quality of oil used as an insulating medium.

This sudden expansion of the arc or gas bubble below the oil line produces a hammer effect on the walls of the oil tank, the frequency of which is at least equal to the natural periodicity of the current. In this phenomenon it is assumed that no explosion takes place. Mr. Burnham stated that in his opinion the pressure wave is of such shape that no part of the breaker except the tank is subjected to any great stress.

Forces due to ignition of chemical combination of gases thrown off during circuit interruption may be of great

magnitude. When the electric circuit is interrupted under abnormal conditions, the action of the electric arc on the oil and arcing contacts causes volatilization, and gases are thrown off. Some of these gases, and particularly certain combinations, if ignited by an electric arc result in an explosion within the tank.

If these gas bubbles are carried up through the oil in relatively small volumes entirely surrounded by oil, the gases are chilled and reach the expansion chamber in a condition which will not tend to cause explosion. On the other hand, if the gas bubbles are extremely large, or if the gas bubbles follow in close proximity so that the small bubbles interconnect to form a large bubble, there is a possibility of the electric arc communicating through this gaseous path with the mixed gases in the expansion chamber to produce explosion above the oil line.

The pressure per sq. in. may easily reach 300 lb. and, therefore, in breakers with a tank diameter even as small as 20 in. the tank bolts and fastenings, tank and switch top must be capable of withstanding an impact of approximately 50 t.

Electromagnetic Forces

The construction of the average circuit breaker (see Fig. 1) consists of a supporting frame or switch top, which carries two insulators per pole, and these insulators in turn support the studs to which the terminal wires are fastened at the air end of the insulator. At the lower end of the insulators a contact block is mounted and so arranged that a movable bridging member makes contact, thus completing the electric circuit.

It is, therefore, obvious that the path of the current in the studs is in parallel planes and at right angles to the plane through the bridging member, thus forming a U-shaped circuit.

Such a condition causes electromagnetic stresses to be set up between the studs and certain reactions are set up in the bridging member from contact with the stationary contact blocks, even though the breaker be in a closed position. Little, if any, difficulty is experienced below 30,000 amp. but at the high current values, say 80,000 to 100,000 amp., the construction and bracing of the main current carrying members must be extremely rugged to withstand these conditions.

Inasmuch as the current which creates the magnetic field around the conductors is alternating, the resultant force is of a pulsating nature and of the same periodicity as the electric circuit.

Assuming that the average breaker requires one-tenth of a second from the time of short circuit to the parting of contacts, it is apparent that on a 60-cycle circuit the conducting parts of the breaker are subjected to 12 pulsating blows, the severity of which varies as the square of the current.

From the foregoing comments it is, therefore, apparent that when a circuit breaker functions under short-circuit conditions for a brief period of time, say 1/10 to 1½ sec., depending on the relay setting, the main conducting parts may be subjected to pulsating forces which vary from 12 to 180 strokes.

During this time, also, the current has reached values many times the rated continuous current carrying capacity of the circuit breaker and as the heating effect varies with the square of the current, the temperature in the conductors reaches an extremely high value, bringing about the expansion of parts, which, acting jointly with the electromagnetic forces, places a tremendous strain on the conducting parts; then at the moment of contact separation the explosive forces within the tanks as aforementioned bring the whole structure under tremendous momentary stress. In addition, during circuit interruption, the clearances under oil are reduced, due to the expansion of the conducting arc gases which are in contact with the conducting parts. This has a tendency to cause flashover, sometimes resulting in the electric arc burning the tank lining, or even burning a hole in the tank itself.

It appears almost unbelievable that a circuit interrupting device could effectively disconnect 1,000,000 or 1,500,000 kv.a. under the above conditions without destruction. With proper design, however, it is possible to interrupt the circuit under these conditions a reasonable number of times with practically no deterioration except of arcing contacts and oil.

Following the foregoing analysis of the stresses acting in a circuit breaker, Mr. Burnham discussed briefly the standards which have been adopted in regard to circuit

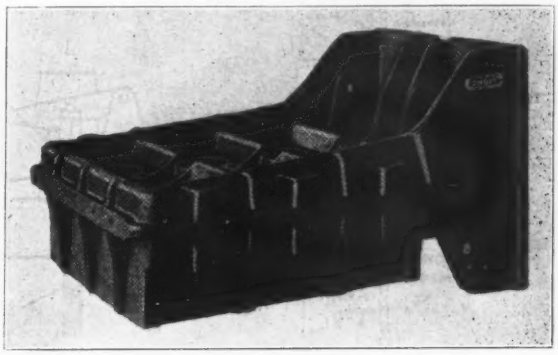


FIG. 2. A STURDY CIRCUIT BREAKER FRAME HAVING A LARGE FACTOR OF SAFETY

breakers by the Electric Power Club and the A. I. E. E. These standards are available to anyone interested so we will not discuss them here, but will proceed with Mr. Burnham's discussion on the constructional features of circuit breakers.

It is evident from the foregoing that the circuit breaker becomes a device in which tremendous internal pressures are set up incident to its operation, which it must withstand without destruction. With this in view let us briefly consider certain fundamentals applicable to the average breaker construction.

The frame of switch top bears the same relation to a circuit breaker as the foundation does to a building. In the design, strength and rigidity of the frame or switch top effect satisfactory operation from the viewpoint of every single function which the breaker is called upon to perform. Strength in a breaker frame is not enough. The frame must be strong and in addition rigid, because a frame which is simply strong may readily yield but not break and such construction in a circuit breaker frame where the tremendous stresses have to be encountered, not only in circuit interruptions but the mechanical stresses that are brought about through toggle actions, have a tendency to cause the frame to spring. This affects the current carrying capacity because no permanency of adjustment may be obtained. It affects the momentary carrying

capacity, particularly due to stresses of electromagnetic nature, because insulators are fastened to the frame and the stresses are, therefore, carried back to this point.

During the circuit interruptions the internal pressures set up may be so great as to deflect the frame to a sufficient extent to bring mechanical strain on the insulators, mechanism and breaker structure. Such is not the case, however, if the breaker frame is designed with sufficient rigidity and in the writer's opinion it is believed that, when dealing with such force and particularly on account of the importance of the circuit breaker in the production schedule, only the most rigid structure should be used on which to assemble the parts which constitute the breaker and that cast frames, heavily ribbed, of rugged design, give the foundation to build on that which will result in satisfactory service without continuous adjustments and maintenance.

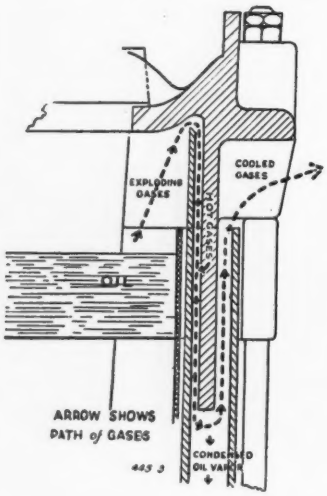


FIG. 3. DETAIL SHOWING METHOD OF VENTING IN A CERTAIN TYPE OF BREAKER

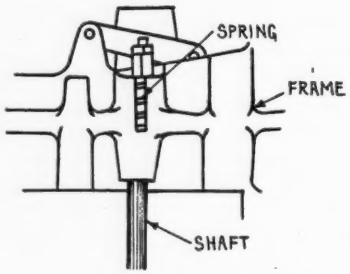


FIG. 4. IN SOME CIRCUIT BREAKERS THE TANK IS SUPPORTED ON SPRINGS AS SHOWN IN THIS DETAIL

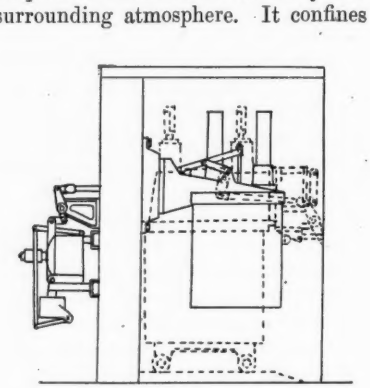


FIG. 6. DIAGRAM TO ILLUSTRATE RELATIVE AMOUNTS OF SPACE OCCUPIED BY THE REMOVABLE TANK AND THE TRUCK TYPE OF BREAKER

In brief, a circuit breaker is no better than the rigidity of its frame and strength alone should not be considered except in connection with rigidity.

Figure 2 shows circuit breaker frames which have been designed with a large factor of safety, particularly with a view of getting rigidity in construction.

Special attention has been given to the ribbing, its location and relation to the stresses set up during circuit interruption. It is argued that resiliency is necessary to cushion impact and it is the opinion of the writer that resiliency interposed at the proper point in the design of the breaker can be used very effectively in resisting and reducing the forces transmitted to tanks, frames and tank bolts, but it is essential that it be interposed at some other place than in the frame itself.

Figure 3 shows this feature of design, which has been very successful. This design is particularly adapted where a minimum of space is available or where it is necessary to replace existing breakers of insufficient interrupting capacity due to growth of system. This design has a rugged, rigid frame with a deep web extending below the oil line. This construction is for the purpose of reinforcing the tank at its open end in order that it may withstand horizontal stresses. The tank, it will be noted, is not fastened rigidly, as is the usual custom, to the frame, but is resiliently supported. (See Fig. 4.) In other words, the tank can move slightly when an interruption causes the pressure within the tank to rise above a predetermined value. As the tank moves, energy is absorbed and the tank fastenings and their connections to the frame of the breaker are not called upon to withstand the tremendous stresses which would have been the case had the tanks been fastened rigidly to the frame. The tank movement automatically vents the breaker. This allows the gases to be forced out of the orifice of relatively large area and to expand into an outer chamber or spill tank. Here the oil vapors are condensed and separated, the gases going to the atmosphere and the oil being retained at the bottom of the spill tank. The double tank construction affords the following features:

It serves as an auxiliary expansion chamber and provides an efficient means for chilling of the gases which reach the main expansion chamber before they are distributed to the surrounding atmosphere. It confines any burning vapors or oil in a deep, narrow, restricted chamber in such a manner that the tendency to combustion is minimized. It safeguards life and property should a hole be burned through the inner tank; in fact, this construction tends to prevent the starting of oil fires. In this respect, it is much more effective than breakers without the double tank features, but surrounded by the usual concrete cell or barrier construction. No added space is required and practically double strength is provided in the tank walls. The added cost is negligible compared to the worth-while benefits which are obtained from the viewpoint of safety to persons and property in addition to effectively safeguarding continuity of service.

In selecting circuit breakers, particular attention should be given to the speed of circuit interruption as it affects the volume of gas generated, which is one factor which determines tank pressures.

Figure 5 shows an effective high-speed contact arrangement employing the use of multi-break construction. Average speed as high as 25 to 35 ft. per sec. may be obtained without causing the contact members or switch mechanism to be accelerated more than 5 ft. per sec. This construction allows reasonable mechanical speeds with maximum speed of circuit interruption, and reduces the mechanical shocks to a minimum. The location of the arcing contact

with reference to the main contacts and insulators affords a free and unobstructed path for the gases to the expansion chamber. The arcing contacts are so arranged that a powerful magnetic action is obtained during circuit interruption, which materially increases its effectiveness in circuit interruption.

Selection as Affected by Maintenance

Opinion is about equally divided among operators regarding the merits of the removable-truck type breaker. Each has certain advantages, depending upon the station construction and arrangement employed. All manufacturers now carry these two types in the moderate and high interrupting capacity classes.

On the question of inspection and adjustment of contacts only, there is really little difference in the time consumed if tank-lifting facilities are provided for the removable-tank type of breaker. If much repair work is necessary, however, the removable unit type offers many advantages, both as to time and ease of repair. The automatic disconnective switch and self-alining switch couplings shown in Fig. 11 allows a switch unit to be replaced in a few moments without the use of tools, and in certain manufacturing processes this feature has a decided bearing on the selection of type.

The removable-unit type of breaker has a decided advantage from the viewpoint of cubic foot per ampere of interrupting capacity. Ten years ago the average cubic foot per ampere interrupting capacity for popular removable tank type 15,000-v. moderate interrupting capacity devices was approximately 0.01. Today it is approximately 0.003. This has been brought about by a better understanding of the phenomena of circuit interruption, by utilizing material of greater strength, use of designs which offer greater resistances to internal pressures by suitably shaping and ribbing of circuit breaker tops, etc., together with much heavier tank construction and tank fastenings than had heretofore been employed.

Removable-truck type breakers utilize the entire cell space to advantage, i. e., the cell space is entirely available for the circuit breaker, whereas in the removable-tank breaker approximately 30 per cent of the cell space is reserved for tank removal and is employed for the purpose for which it is intended only a few moments during inspection or repair period. In certain localities and under certain conditions, this space is exceedingly valuable, but it is obvious that by referring to Fig. 6 the removable-truck type breaker effectively utilizes all the space and has in the majority of instances a relative space factor as low as 0.001.

It is interesting to note these approximate figures, as they indicate that it is possible to increase the interrupting capacity of the older installations about 8 times without tearing down cell structure, bus compartments, etc. The present-day breakers also have a much larger factor of safety for insulation and, therefore, the replacement of existing breakers not only provides increased interrupting capacity, but also materially increases the factor of safety of a system from the viewpoint of insulation.

It hardly seems necessary to comment on the use of the air circuit breaker on systems of moderate or high interrupting capacity, or on moderate voltages where the energy necessarily has to be interrupted in a restricted space; however, where economic conditions permit, it is used on low voltage alternating-current circuits of low interrupting capacities.

While the first cost of circuit breakers is of utmost importance, the overall cost of that part of the contemplated installation which is determined by the space requirement of the breaker is the determining factor from an economic point of view. This is, indeed, of greater importance when considering replacement of existing breakers. Here not only minimum space, but particularly the width of the breaker is usually the determining factor in the cost of contemplated changes, for it is usually the width of the breaker which determines, after all, whether or not extensive modifications are necessary in cell structure, bus arrangements and building extensions.

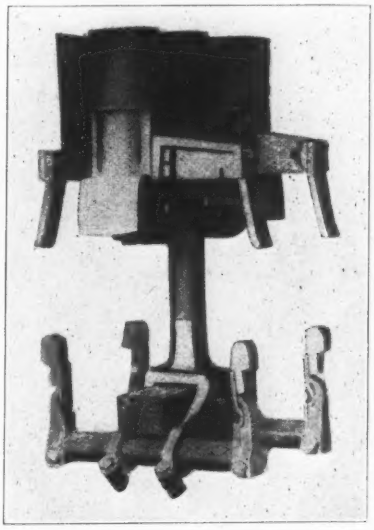


FIG. 5. AN EFFECTIVE HIGH SPEED CONTACT ARRANGEMENT

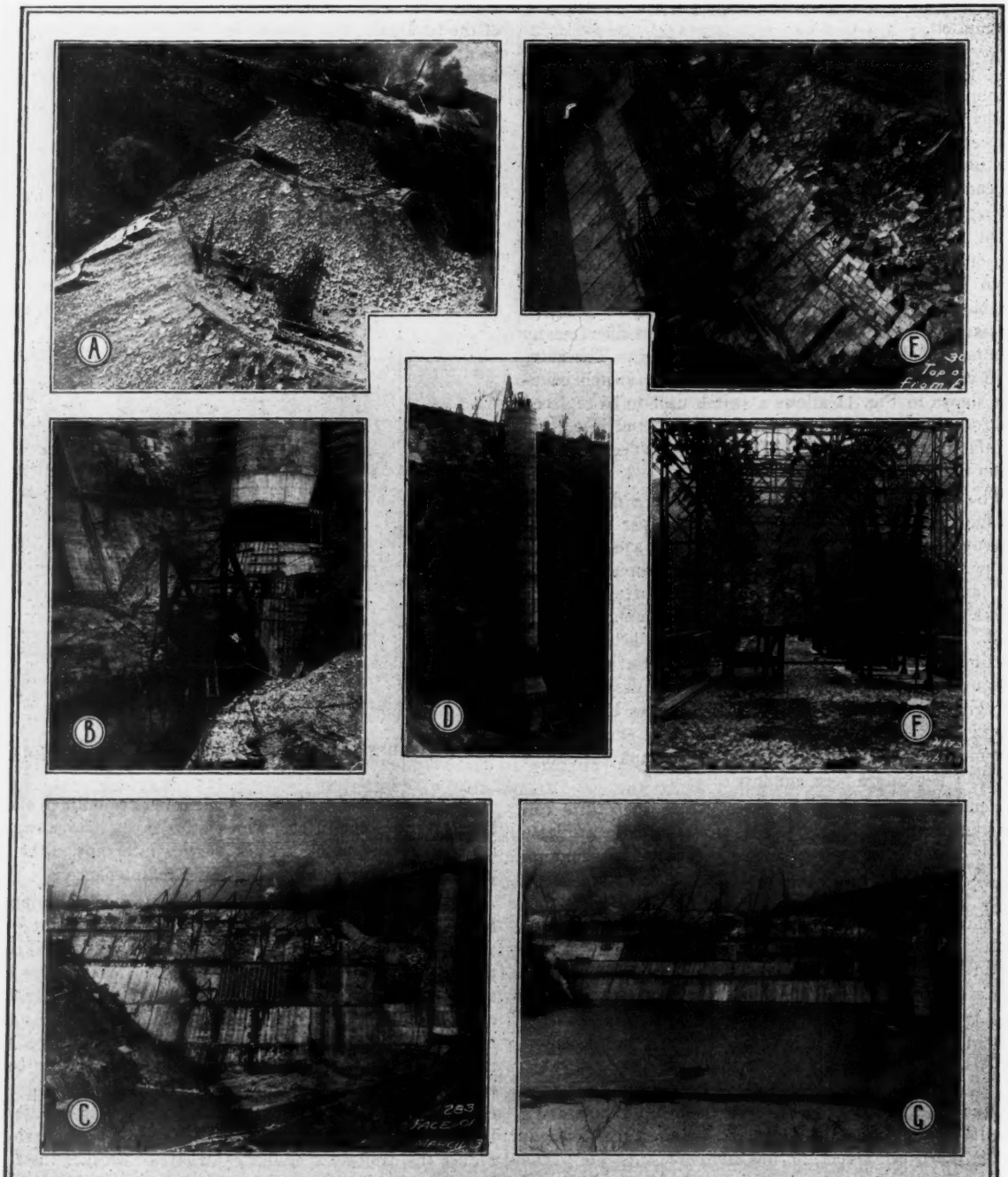
With improved and more efficient devices built to stand harder service conditions, which arise as the power capacity is increased, will come less service interruption, better production and possibilities of lower maintenance.

Circuit breaker manufacturers appreciate their problems, their duty to the industry, and the important part which the switching equipment plays in the successful control of the increasing power demands. Conservative designs, with higher factors of safety, both mechanically and electrically, will tend to minimize service interruptions and maintenance charges, without adding materially to the installation cost. Already considerable progress has been made in keeping down the space requirements of oil circuit breakers and, with contemplated designs, it is believed that future development along this line will materially reduce the capital expenditures of circuit breaker installations as a whole.

Correction Note

Our attention has been directed to a typographical error in the article "Simple Tests Show Quality of Leather Belting," by Louis W. Arny, in the October 1, 1925, issue. On page 1011, first column, tenth line from the top, the words, "or a double belt 7/64 in. thick" should read, "or a double belt 17/64 in. thick."

Construction Work at Dix River Dam



A—Rock fill was dumped into the river bed in a series of lifts as shown, the top of each lift being leveled for working space. Most of the fill material was taken from the spillway excavation. B—Bottom of intake tower and upstream portal of diversion and pressure tunnel, showing hemispherical steel flap gate, and inlet ports around circumference of tower. C—This view of dam, before diversion tunnel was closed, shows method of handling material with inclined cables and derricks. Intake tower at the right. D—Another view of the intake tower, showing the hoist at the top for raising and lowering the concrete plug valve. E—Details of construction of dam. Dry rubble masonry was laid on fill, following up with concrete water-tight slab. F—Outdoor substation for stepping up power to 33 and 66 kv. for transmission over the 110-mi. transmission system. G—After the intake tunnel was closed, the lake filled up slowly, and work on the concrete facing wall was carried on ahead of the rising water. The storage basin thus formed is 34 mi. long and is known as Lake Herrington.

Dix River Dam and Power House Completed

LARGEST ROCK-FILLED DAM IN THE WORLD STORES WATER IN 34-MI. LAKE TO FURNISH 33,000 HP. FOR KENTUCKY HYDRO-ELECTRIC CO.

WITH THE RECENT completion of the dam and power house of the Kentucky Hydro-Electric Co. on the Dix River near High Bridge, Ky., 33,000 hp. has been made available for use and a lake 34 mi. long, known as Lake Herrington, has been created by the Dix River Dam, 920 ft. long, 275 ft. high, and 700 ft. thick at the base, the largest rock-filled dam in the world and the highest dam east of the Rocky Mountains.

In the power house, which is located at one end of the dam on the downstream side, as shown in Fig. 1, are installed three vertical, single-runner water turbines rated at 11,000 hp. each. These were furnished by the Wm. Cramp & Sons Ship & Engine Building Co.; they have cast steel scroll cases, discharge into Moody spreading draft tubes and are governed by Woodward governors. They operate at 300 r.p.m., and drive vertical 9400 kv.a., 13,200-v., 3-phase, 60-cycle Allis-Chalmers generators with direct connected exciters. The operating floor is at the elevation of the top of the stator.

Ventilating air, drawn into the downstream side, passes through the low tension bus room to the generator pedestal, from which it is discharged, by fans in the rotor, through the chamber housing the generator and thence into the atmosphere through the ventilating sash on the upstream side or through floor registers into the generator room as needed.

Energy for transmission to Louisville, Lexington and Pineville is stepped up to 66,000 v. in an outdoor substation, shown at F in the preceding page. For nearby cities, 33,000 v. will be used. A 110-mi. transmission line has been constructed in connection with this development.

Construction of the dam, spillway and intake tunnel have presented many problems and the work has been of great interest to all hydraulic engineers during the past year. In addition, a waterworks pumping station and filtration plant had to be rebuilt for the city of Danville, together with two highway bridges which were flooded. One of these bridges is of particular interest because, in order to set the deck of it 250 ft. above the original river level, it was found advisable to abandon the usual cantilever and suspension construction and to use as piers two hollow, reinforced-concrete chimneys. Across these piers three spans were erected by the cantilever method; the piers will be almost entirely submerged when the reservoir is filled.

INTERESTING CONSTRUCTION FEATURES OF ROCK-FILLED DAM

For this development a rock-filled dam was suggested when partial development was first proposed, as a type that would lend itself to increase in height later on. When it was finally decided to develop the entire head from the beginning, investigation of this type was continued and it was finally selected in preference to concrete structures.

Illustrations on the preceding page show how the dam was constructed and Fig. 2 is a section through the dam. The structure has a fill of limestone, resting on the limestone foundation formed by the river bed, with a facing wall of dry rubble masonry about 14 ft. thick at the base of the dam, 7 ft. thick at water level and 4 ft. at the crest. On this rubble wall is laid a water-tight element consisting of reinforced concrete slabs, 18 in. thick at the base of the dam and 8 in. thick at the crest.

Through a depression in the hill adjoining the dam, a spillway channel was cut. This spillway is of large size, because the rock was needed for the dam. The maximum recorded flood of the Dix River drainage area, during 13 yr. of daily observation, was about 28,000 sec.-ft. and the spillway will carry 200,000 sec.-ft., thus insuring safety against over-topping of the dam.

Filling was begun by blasting down about 100,000 yd. of material from the adjoining cliffs and the remainder of the filling material was brought from the spillway by steam

FIG. 1. DIX RIVER POWER HOUSE CONTAINS THREE 11,000-HP. HYDRO-ELECTRIC GENERATORS

locomotives and dump cars. The first lift was 120 ft. high, the fill being built out from the west side of the river, the dump track assuming a semi-circular form as the fill built out. Succeeding lifts were 60 ft. high, built by dumping from trestles, except in the case of the top lift. The latter was built by jack-track method, in order not to leave too much timber in the fill and to avoid interfering with the building of the wall. C and E show how the face wall was laid, followed by the concrete slab.

This reinforced concrete facing slab is one of the interesting elements of the design. It was first designed in slabs 8 ft. square but, after investigation of the settlement of other dams of this type, this was found unnecessary. Instead, the material was poured in larger sections, provision being made for expansion joints; the vertical joints are 48 ft. apart and the horizontal joints about 70 ft. apart, the latter measured along the slope of the dam. Compressed cork was used for expansion joint material and U-shaped copper seal strips to join the slab to the vertical ribs. Concrete was designed and controlled to obtain a strength of 3000 lb. per sq. in. in 28 days; the designers have calculated that, considering the slab as a beam uniformly loaded, a deflection of about 1.73 in. at the bottom of the upstream face, increasing to 3.5 in. at the crest, could occur in the 48-ft. width of slabs between expansion joints without exceeding the safe unit stresses in the slab.

Since the pouring of the facing on a slope of about 1.1 horizontal to 1 vertical, as shown in Fig. 2, necessitated the

use of an upper form, it was decided to make the forms of special design from the river bed to elevation 670 and to leave the forms in place. Accordingly, these forms were built of 3-in. by 10-in. well seasoned yellow pine, tongued and grooved, laying the planks with the rough side down and firmly bolted into the concrete. It is believed that this lumber will swell to form a tight diaphragm and that it will form the first line of defense against seepage through the face of the dam.

Concrete for the slab was mixed in a central mixing plant at crest elevation at the west end of the dam, and distributed by a system of inclined cable and buggies. Three-inch grout holes of varying depths, shown in Fig. 2, were drilled through the cutoff wall, the first series about 40 ft. apart and varying in depth between 200 and 250 ft. These were followed by intermediate holes of less depth, resulting in 20 ft. spacing and then by another series of holes of 10 ft. spacing and finally by a 5-ft. spacing where found necessary.

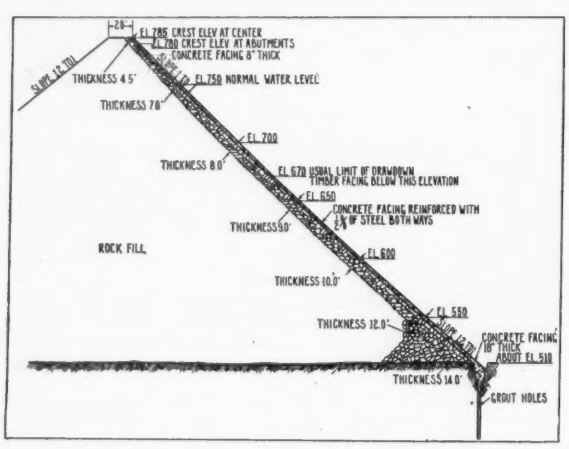


FIG. 2. SECTION THROUGH DIX RIVER DAM

On the preceding page, the rock fill, with its facing wall of rubble masonry, and the lower part of the concrete slab are shown at E. At C is shown the dam before the intake tunnel was closed and at G the formation of the lake after closing. Figure 1 shows the power house and tail race as they appear at present.

To divert water during construction work, a diversion tunnel 913 ft. long and of horseshoe section, 24 ft. by 24 ft. was cut through the rock and lined with concrete. After this tunnel was closed, it became the pressure tunnel and three 8-ft. penstocks lead from the lower end of it to the power house. The upstream portal of this tunnel was led out on the upstream face of the dam as shown at B, C and D, and a structural steel circular flap gate, 26 ft. in diameter, was installed as shown, hinged above the tunnel and closing on a cast steel seat in the portal. This gate, designed to withstand a total head of water of 225 ft., consists of a cast steel rim to which there is riveted a plate steel hemisphere concave upstream, thus putting all plates and joints in tension.

Intake Tower Built to Control Flow

Since this diversion tunnel is to serve as the pressure tunnel, the tunnel section was extended as shown to form the base for an intake tower. This tower, shown in C, D and G, is a reinforced concrete chimney, 22 ft. in diameter inside and provided with ports around the circumference. These ports are closed by a concrete plug, about 30 ft. high, with sealing rings, moving vertically in the tower and hoisted up and down by a 15-hp. motor driving an oil-pressure hoist at the top of the tower. This plug weighs 575 t., the great weight having been provided on account of the need which then appeared possible for its use to exhaust flood waters before completion of the dam, through the intake ports and down into the tunnel, after closing of the hemispherical gate described above.

Dix River Dam and power house were designed by L. F. Harza, hydro-electric engineer, Chicago, to whom we are indebted for data and photographs of this project. George W. Howson was resident engineer and the L. E. Myers Co., Chicago, were the contractors.

Government Estimates Columbia River Water Power

ENGINEERS OF THE Geological Survey have made several preliminary estimates of the water-power resources of Columbia River proper, according to a recent statement of the Department of the Interior. Over 8,000,000 acres of land can be irrigated within the drainage area of Columbia River, of which about 3,600,000 acres is irrigated now. The river can be made navigable from its mouth to the international boundary, a distance of 760 mi., if proper foresight is exercised in the location of dams constructed primarily for use in developing water power. The latest estimate, summarized below, indicates that about one-seventh of the potential water power in the United States is to be found along Columbia River, exclusive of the large power resources on its tributaries.

SUMMARY OF POTENTIAL POWER ALONG COLUMBIA RIVER

(Horsepower at 70 per cent efficiency.)

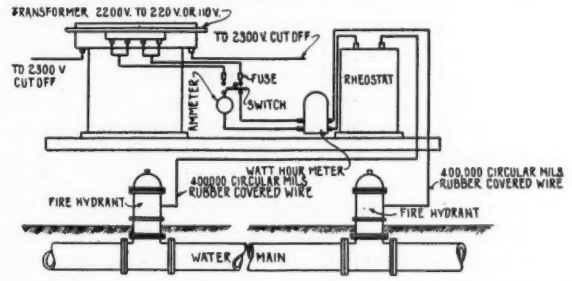
	90 per cent of the time	50 per cent of the time
Total in Washington:		
Natural flow	3,108,000	6,354,000
Regulated flow	3,846,000	6,568,000
Total in Oregon:		
Natural flow	846,000	1,488,000
Regulated flow	949,000	1,408,000
Total:		
Natural flow	3,954,000	7,842,000
Regulated flow	4,795,000	7,977,000

A blueprint of a table that indicates the dam sites on Columbia River and gives the estimated flow and potential power at each site can be obtained by application to the district office of the Geological Survey, 404 Federal Building, Tacoma, Washington.

Determination and Calculation of the total and partial vapor pressures of aqueous ammonia solutions, and their application to the absorption ammonia process illustrated by a concrete example, are the subjects dealt with in Bulletin No. 146, entitled "The Total and Partial Vapor Pressures of Aqueous Ammonia Solutions," issued by the Engineering Experiment Station of the University of Illinois.

Frozen Water Pipes Thawed by Electricity

DURING the past winter this city experienced serious trouble with the freezing of service pipes to buildings, fire hydrants and short lengths of water mains. To overcome this trouble and get immediate relief, I arranged the apparatus as shown in the accompanying illustration. The distribution service of the city is 2300 v., but by a combination of transformers this was stepped down to 110 v. or 55 v., according to the length and size of pipe to be thawed.



PROFITABLE ASSEMBLY OF TRANSFORMER, METERS AND RHEOSTAT FOR USE IN THAWING WATER MAINS

For fire hydrants and short lengths of pipe 55 v. is ample, as the transformer capacity can be varied from 10 to 50 kv.a., according to the service required. Both the transformers and lead wires may be overloaded, as the period of overload is brief and the outside air temperature low. The whole assembly, placed on a trailer, may be easily moved to any desired point.

Normally to thaw cast-iron pipes, values of current given in the following table are sufficient:

TABLE OF APPROXIMATE CURRENT VALUES FOR THAWING PIPES OF NORMAL RESISTANCE

Pipe diam., in..	3	4	6	8	10	12	14
Amperes	280	390	600	800	1200	1400	1650

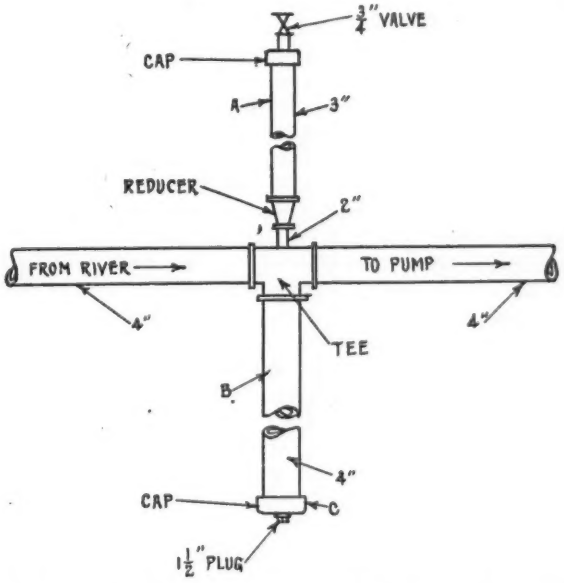
Before proceeding with the thawing of pipe lines, the resistance per unit length should be measured to determine the character of the pipe joints. High resistance usually denotes corrosion at the couplings and may necessitate higher voltages and heavier loads. Much of the work was on pipes varying from 10 in. to 1 in. diameter.

For the smaller service mains, 1 in. to ½ in., in residential sections of the city, where only 220 or 110 v. were available, a small transformer was built out of some old ones found in the shop. Being portable and with the potential reduced to about 12 v., it was light and safe to handle. The primary winding of this transformer consisted of 530 turns of No. 11 (single cotton, enameled) magnet wire, divided into two windings of 265 turns each, connected in parallel for 110 v. and in series for 220 v. The secondary was made up of 40 turns of No. 2/0 or 1/0 magnet wire. Since this transformer was air cooled, it was placed in a neat, well ventilated box and the primary terminals brought out to an externally fused knife switch.

Woodward, Okla. HARRY J. ACHEE.

Vacuum Chambers for Pump Do Double Duty

RECENTLY, I witnessed the operation of a pumping unit, the details of which might be worth describing. The suction pipe is 4 in. in diameter, 80 ft. long, and has a vertical lift of 22 ft. As shown by the accompanying sketch, a piece of 3-in. pipe A and a piece of 4-in. pipe B were installed to act as vacuum chambers, both pipes being capped and the 4-in. cap C drilled and threaded to take a 1½-in. plug. When there was heavy rain and during the spring thaws, sand and other material found its way into the pump through the suction pipe.



SUCTION LINE OF PUMP HAS A CHAMBER FOR VACUUM AND ONE FOR SEDIMENT

Originally only the pipe A was installed, then B was added, the idea being to increase the volume of the vacuum chamber and also to form a sand catcher. These chambers are within a few feet of the pump. When chamber B is to be cleaned out, the suction pipe is emptied and the plug then unscrewed. If this plug should be unscrewed

while the suction pipe is filled, even with the pump not working, the vacuum caused by the water leaving the pipe would pull the dirt up out of the chamber and into the pipe where a certain amount of it will remain along the bottom of the suction pipe to be drawn again into the settling chamber or into the pump. It is necessary, therefore, that precautions always be taken to break the vacuum before attempting to clean the settling chamber.

As shown in the sketch, a hand-operated vent valve is connected to the cap at the top of pipe A, which valve must always be opened before removing the plug at the bottom of C. The valve at the top of pipe A should be regularly inspected for air leaks, as a leak at this point will destroy the efficacy of the vacuum chamber.

Toronto, Canada. JAMES E. NOBLE.

Cost of Generating Power in the Mill Power Plant

THE ARTICLE by Morgan G. Farrell in the Sept. 1 issue contains valuable information on electrical equipment of cotton mills, but the statements concerning the cost of generating current in the mill power plant are open to discussion. For instance he states that a well managed mill attempts to generate current for less than 3.25 cents per kw-hr. and even with the new engineer the cost exceeded 4 cents. Let us analyze his cost figures and see where the cause of this high figure lies. He states that 7,500,000 kw-hr. were generated per year at a cost for fuel and supplies of $225,000. Supplies in plants of this size seldom cost over $10,000 a year which leaves $215,000 a year for fuel. A good grade of coal is available for $7.00 per ton delivered to the boiler room, and this means that the annual fuel consumption was around 30,700 T., which indicates a rate of 8.18 lb. of coal per kw-hr. This is obviously unreasonable in view of a modern generating unit having been installed. I can point to many plants of that type over 20 yr. old, which can show a rate of 4 lb. per kw-hr.

In contrast to Mr. Farrell's plant, let us consider a cotton mill in western Massachusetts which, since 1919, has generated all its own power. The plant has a capacity of 3000 kw. and with an operating schedule of 2400 hr. per yr. the annual output is over 7,000,000 kw-hr. and the power costs are about as follows: The turbine water rate of 15 to 17 lb. per kw-hr. gives a fuel consumption of 14,000 t. per yr., including auxiliaries, evaporation being around 9 lb. of water per lb. of coal. The plant cost, to install, about $275,000, the cost being apportioned as follows: Turbines $105,000, including foundation and erecting. Boiler and stoker, $49.00 per hp. complete, making the cost of three 625-hp. units $91,875. Piping and switchboard wiring, $22,000, auxiliaries, including coal and ash handling machinery, $20,000, and building construction, $36,000. Fixed charges at 12.5 per cent on this amount give an annual capital cost of $34,375; fuel, which costs this firm $6.70 per ton unloaded in the bunker, comes to $93,800 per year. Labor costs include two engineers, three firemen, one repairman and two helpers and amount to $13,600 per year, including replacements.

Thus the total cost of 7,000,000 kw-hr. per year is less than $150,000 per year, or a unit cost of 2.14 cents per kw-hr. This figure is far closer to the mark than Mr. Farrell's figure for the average cotton mill and includes the cost of new boilers, which are not mentioned in his report.

A very likely error into which Mr. Farrell may have fallen is the practice of charging all fuel and labor costs to power generation when any engineer knows that even with purchased power, we must install boiler and piping, build a boiler house, line firemen and burn fuel to heat the mill in winter, and this costs money. Now, since the mill under discussion is located in Massachusetts, we can assume that a mill large enough to require a plant of 3000 kw. or larger will require for heating anywhere from 10,000 to 12,000 lb. of steam per hour in winter and if this steam is supplied by steam bled from the second stage of an extraction turbine, obviously we must deduct this amount of steam, when figuring power costs. Mr. Farrell's figure of 8 lb. of fuel per kw-hr. probably includes the coal for heating, for even in old reciprocating engine plants this is a high figure.

Mr. Farrell will do well to consider the practice of a certain well known builder of uniflow engines, who installs his engines on an iron clad guarantee that they will save money over the cost of purchased power, where the rate is 3¼ cents or over for purchased current. This is done by a plant along these lines. If the boilers are in good shape and good for 135 lb. pressure or over the engine builder will install his engines on an extremely small cash payment, frequently as low as $5.00 per kw. and the engines are not paid for till the amount of the purchase price has been saved through economies effected by them. In a plant of 3000 kw., doubtless two 1500-kw. uniflow units and one 500-kw. would be applied and in winter the exhaust of the small unit could be applied to heating and the power from this unit is secured at practically no fuel cost. Possibly the high cost in the plant referred to by Mr. Farrell is due to improper design, for the writer knows of some mills where all engines are operated condensing in winter and live steam used for heating, a practice which greatly increases power costs. Or consider a Diesel plant where no process steam is required except for heating, costing $250,000 ($83.33 per kw.). At 12½ per cent fixed charges, 0.6 lb. of fuel per kw-hr. and $5000 per yr. for labor, $10,000 for replacement of parts and supplies, the total annual cost is only $82,500 a year, which gives a unit cost of 1½ cents per kw-hr. and a reduction of this amount is possible if the exhaust is used for heating in winter, by generating low pressure steam with jacket water and an exhaust heater or boiler.

Springfield, Mass. A. F. SHEEHAN.

Protecting the Inside of Tanks From Water Surge

SOMETIMES water supply pipes to storage tanks enter the side of the tank. Water entering any kind of tank through the end or side should have the end of the pipe extending far enough into the tank that the entering water will not flow against the inner edge of the threader or drilled hole in the plate or flange.

At the Ontario Government Hospital in Toronto, some years ago, I had this demonstrated to me quite convincingly. A 2-in. flange was riveted to the side of a water storage tank into which a 2-in. circulation pipe was screwed, but the threaded end of the pipe was not long enough to go all the way through the flange. After being in use about 15 yr. a leak started at the edge of the flange.

Attempt to calk the leak proved useless, so the flange was cut off the tank. The constant surge of the water had not only worn a ridge in the tank iron, but a rivet head inside the tank was also completely worn away.

Of course feed pipes and circulation pipes should not be connected to the sides or ends of tanks in this way, but the fact remains that many are and although it should be obvious to any mechanic that the side of a tank is not the proper location for a circulation pipe, it should be noted that many hot water boilers or tanks for domestic use are still being manufactured with side holes for the circulation pipes. An experienced pipe fitter will usually plug such holes and carry the circulation pipe to the top of the boiler.

Toronto, Canada. EDWARD JAMES.

Homemade Appliance Often Inferior

ON LOOKING through a magazine the other day, nearly 50 yr. old, I was interested in reading an advertisement headed, "How to Make a Phonograph."

It struck me as unusually interesting because I have never heard of anyone trying to make a phonograph. We of the younger generations have always left that to the manufacturers of phonographs. However, on second thought, I recall that when a boy my playmates and I tried to make our own crude bicycles. When the automobile engine was more recently developed, we bought castings and tried to make our own engines for driving bicycles and some of us succeeded. I made a small steam turbine. We also made electric dynamos and motors. But all of those crazes are events of the past. And now that the radio is introduced, we find that a great many people get more pleasure out of making their own radio sets than they do in listening or in buying them.

Thus, it appears that immediately following a new mechanical development, there is a craze for making it one's self which craze soon dies out upon finding that homemade products are seldom as good as those manufactured by specialists.

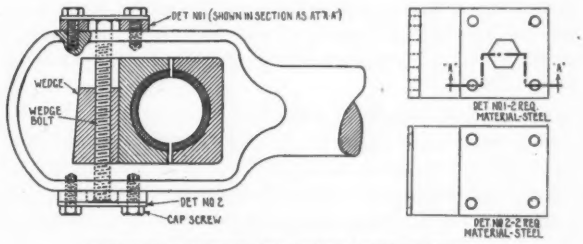
Newark, N. J. W. F. SCHAPHORST.

Broken Wedge Bolt Caused Engine Shutdown

IN A certain plant there was a 1000-hp. tandem compound engine which had to run from 7 a.m. Monday till 6 a.m. the following Sunday without a stop. If this schedule was not maintained, the plant engineer had to give satisfactory explanation to the office. But every two or three weeks an enforced shutdown happened on account of the fracture of the wedge bolt in the crankpin boxes and no one was able to locate the cause of the trouble. We had to keep six or seven spares on hand all the time in readiness for the emergency and we lost practically 30 min. running time every time a new wedge bolt was put in. The engine was not out of line in any direction and the rod was not sprung. There was no appreciable wear in the slot in the rod and the boxes were a good fit. We always had difficulty removing the bolt after breaking, as it was usually slightly bent. As steel bolts were used, the trouble could not be laid to defective material, and, in fact, no possible reason could be found for the repeated breaks.

Finally, I suggested that the broken bolt be held in some way to prevent slacking of the wedge and thus the engine could be kept running till Sunday, when a new bolt could be put in. So that week end, the plant engineer and myself devised a scheme to hold the bolt and wedge in place even after the bolt had fractured.

As shown in the accompanying diagram, four steel plates, 6 in. by 4 in., were provided. In the two which were of the same thickness as the head and nut on the wedge bolt, holes were burned with a torch and milled so that they would just slip over the head of the bolt. Then all four had holes drilled and tapped for four ½-in. cap screws, four in each piece. Four holes on the top and bottom side of the connecting rod were drilled and tapped with the same center to center distances as in the steel plates. After inserting a new wedge bolt, the clearance between the boxes and pin was adjusted as usual and the wedge bolt tightened. Then one of the pieces with the hexagonal opening was placed on top of the rod, the head of the bolt entering the opening. Next, one of the solid pieces was laid over this and the whole assembly secured by four ½-in. cap screws. The other two pieces were



SCHEME DEVISED TO HOLD WEDGE BOLT

secured on the bottom in the same way. The inner plates with the milled holes prevented the halves of the bolt from turning after breaking and the outer pieces prevented their backing out. The wedge was rigidly held in case of a fracture of the bolt and though the bolts continued to break, we continued to finish the run through the week and dismantled the plates each Sunday for inspection of the wedge bolt.

Workmen from a nearby engine repair shop suggested that the trouble might be due to high steam pressure, but could think of no other reason, even after inspecting the engine. With the load we were carrying, it was out of the question to reduce the pressure even had that been the cause of the trouble. The crankpin was 11-in. in diameter and 11-in. long and the thrust per square inch of projected area was figured to be 619-lb. I know of many engines with a greater load on the crankpin bearing, which run without trouble.

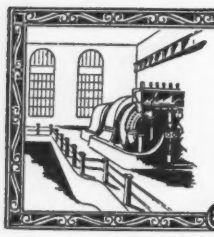
Chicopee, Mass. J. A. MADSEN.

Back Pressure Caused by Exhaust Head

IN A NEIGHBORING factory the exhaust pipe of a large Corliss engine was equipped with an exhaust head of galvanized iron. One day the dash pot at one end of the cylinder failed to hook up, due to worn catch plates or some other cause, and the engine gave a few loud snorts and blew the top off the exhaust head.

Indicator diagrams had been taken before this happened. Upon taking diagrams some time after the accident with the remainder of the exhaust head still in place, there was found to be considerable reduction in the back pressure. It is evident that the exhaust head was too small or improperly constructed. There is nothing gained by putting on one which acts as a brake.

Burlington, Iowa. TOM JONES.



QUESTIONS AND ANSWERS

Boiler Horsepower Equivalent of Radiation

OUR plant is equipped with two 72 in. by 20 ft. h.r.t. boilers, with 66 4-in. tubes per boiler and each boiler has a 125-hp. rotary oil burner. Our heating demands are 34,000 sq. ft. of radiation. Can one of these boilers carry the load if a larger burner is installed? What size burner is required? A. N.

A. According to the data you have given, your boilers each contain 1596 sq. ft. of heating surface which, according to the standard rating of allowing 10 sq. ft. for each rated b.hp., gives them a rating of approximately 160 hp. each.

Since you may be interested in knowing how the heating surface of these boilers is determined, we may state that there are three items to be calculated. First, the number of square feet of surface around all the tubes; second, one-half the surface of the shell; third, the area of the back head minus the area of the tube openings.

Since your boiler is 20 ft. long and contains 66 4-in. tubes and the circumference of a 4-in. tube is 12.57 in., then the circumference of one tube in feet is 1.05. Multiplying this by 20 gives 21 sq. ft. of surface on each tube. Multiplying by 66 gives 1386 sq. ft. of surface on all the tubes. The circumference of a 6-ft. circle is 18.8 ft.; multiplying by 20 gives 376 sq. ft. of surface on the entire shell; dividing by 2 gives 188 sq. ft. of surface exposed to the fire.

The area of the entire rear head is 28.2 sq. ft. The area of a 4-in. circle in feet is 0.0872, multiplying by 66 gives 5.76 sq. ft.; subtracting this from 28.2 gives 22 sq. ft. as the surface exposed on the rear head. Then, adding 1386, 188 and 22 gives 1596 sq. ft. of heating surface for the entire boiler.

One square foot of standard cast iron steam radiation is assumed to transmit 250 B.t.u. per hr. Since 1 b.hp. is 33,524 B.t.u., then $33{,}524 \div 250 = 134$ sq. ft. of radiation as the equivalent of 1 b.hp. or 1 sq. ft. of radiation = 0.00756 b.hp. Since you have 34,000 sq. ft. of radiation, the hp. necessary to produce this amount of heat will be 254.

You state that each boiler is equipped with a 125-hp. rotary oil burner. This is about the allowable limit for one burner at rating, but it may exceed this capacity by 50 per cent. Even then, one burner would not be enough to give you 254 hp. It is ordinarily better to have two oil burners of the present size instead of one large burner.

Of course, since your furnace is only approximately 6 ft. wide, there may be a question as to whether you can install two burners and not have the flame from one burner interfere with the flame from the other. It depends on the angle of divergence of the flame.

You have not stated the kind of oil used but various fuel oils do not vary in heat value nearly so much as coal and for the ordinary commercial fuel oil of 24 to 26 deg. Be., 18,750 B.t.u. per lb. may be taken as an average figure. This oil will weigh about 7½ lb. per gal.

You have not stated the height of your boilers above the floor line, so that we cannot figure the size of the combustion space. This is important, for it may be, if your boilers are set too low, that it would be useless to attempt to install another burner under each boiler or put in one larger burner under each boiler.

To get good results, you should have at least 1 cu. ft. of combustion space for each 18,000 to 20,000 B.t.u. liberated per hr. If you want to develop 250 hp. with one boiler, then $250 \times 33{,}500 = 8{,}375{,}000$ B.t.u. needed. Since your equipment is not 100 per cent efficient but may possibly develop 70 per cent, if the combustion space is large enough, you will need to burn enough oil to liberate 11,965,000 B.t.u. per hr.

If we assume 1 cu. ft. of combustion space for each 18,000 B.t.u. liberated, then you will need 665 cu. ft. of combustion space. This refers to furnace volume before the gases enter the tubes. It also means that you cannot figure that part of the furnace back of and below a horizontal line extending across the top of the bridge wall, as this is practically dead space. The boiler must, therefore, be set high enough to give you 665 cu. ft. of active combustion space. If your boilers are not set high enough to do this, we would not advise you to attempt to install any larger burners than the present 125-hp. type which you now have. It would mean, in order to carry your load of 250 hp., that you could not operate one boiler more than 150 per cent of rating, possibly not that much, and that the rest of the load would have to be carried with the other boiler.

Economizer Advantages and Costs

IF YOUR superiors were planning the installation of an economizer in your plant and you felt in your own mind that it would be a waste of money, how would you convince them? A. A. W.

A. Factors for determining installation of economizers must be considered under advantages and costs. Among the advantages are:

1. Saving in fuel ranging from 7 to 20 per cent.

2. Overall boiler superheater and economizer efficiency ranging from 90 to 93 per cent.

3. A substantial overall gain in heat economy where the boilers are operated with high flue gas temperature.

4. Maximum overall heat economy when the boilers are forced far above their rating and auxiliaries are electrically driven and pure feed water is available. This is true only for the conventional type of turbine or engine. If the feed water is heated by bleeding the prime mover, the gain from the economizer becomes less as the temperature of the feed water is increased.

5. Decreased wear and tear on the boilers due to the higher feed water temperatures.

6. The large storage of hot water for sudden heat demands.

Costs to secure these advantages are:

1. First cost and maintenance of the economizer.

2. Cost of power requirements of induced draft fan.

3. Treatment of feed water to prevent internal corrosion.

4. Extra space requirements for economizer equipment.

These costs may be of such proportion that they will offset gains which might be made by installing the economizer and each case must be carefully considered on its own merits.

How Much Water Is Needed for Condensing?

INJECTION water for a surface condenser has a temperature of 55 deg. F. It is heated to 120 deg. F. by passing through the condenser. The temperature of the condensed steam is 135 deg. and it is exhausted into the condenser at 3 lb. absolute pressure. What is the quantity of condensing water required per pound of steam?

C. M. S.

A. The answer may be obtained by the following formula:

$$R = \frac{H - t_1 + 32}{t_2 - t_0}$$

where R = the weight of injection water necessary to condense and cool 1 lb. of steam, t_1 = the temperature of the condensate, t_2 = the temperature of discharge water, t_0 = the temperature of injection water and H = heat content of exhaust steam above 32 deg.

Then, according to the conditions of the problem,

$$R = \frac{1122 - 135 + 32}{120 - 55}$$

which gives 15.65 lb. water necessary to condense and cool 1 lb. of steam.

Maximum CO_2 Depends on Hydrogen Content

WHEN burning 25 deg. Bé. fuel oil, what is the theoretical maximum CO_2 which may be obtained and what CO_2 should I get with 25 per cent excess air and complete combustion?

A. R.

A. Since you have not given an ultimate analysis, we will assume, for oil of this gravity, 86 per cent carbon, 13 per cent hydrogen and 1 per cent oxygen. In any fuel containing carbon and hydrogen the theoretical maximum CO_2, which may be obtained when burning the fuel with no excess air, is dependent on the amount of hydrogen present.

Air contains 20.9 per cent oxygen by volume and, if a fuel were all carbon, there would be 20.9 per cent CO_2 formed when there is no excess air and the combustion is complete. Since water is formed in burning hydrogen but is not measured in gas analysis, the more hydrogen a fuel contains, the less will be the maximum CO_2 obtainable. This may be calculated by the following equation:

$$\text{Theoretical maximum } CO_2 = \frac{20.9}{1 + [2.38\,(H - 0/8) \div C]}$$

Substituting the assumed values of the above ultimate analysis, we have:

$$\text{Maximum } CO_2 = \frac{20.9}{1 + [2.38\,(0.13 - 0.01/8) \div 0.86]} =$$

15.4 per cent.

The actual CO_2 obtainable with any given amount of excess air may be found by the equation:

$$\text{Actual } CO_2 = \frac{\text{Theoretical } CO_2}{1 + \text{per cent excess air}}$$

In this case, the actual CO_2 with 25 per cent excess air will be: $15.4 \div 1.25 = 12.3$ per cent.

Vacuum Corrected to Standard Conditions

PLEASE state what the vacuum reading should be when referred to a 30-in. barometer if the barometer reads 29.27 in. and the height of the mercury column in the vacuum gage is 25.9 in.

S. R. B.

A. In this latitude, standard atmospheric pressure is 29.92 in. of mercury at 32 deg. F., but since, in condenser work, the vacuum gage is referred to a 30-in. barometer, it is necessary to increase the standard temperature to such a degree that it will increase the height of the barometer from 29.92 to 30 in. This is found to be 58.15 deg. F. Accordingly, if the vacuum gage and barometer readings are corrected to this temperature of 58.15 deg., the difference between the figures will give the absolute pressure in inches of mercury at 58.15 deg. If the difference is subtracted from 30 in., the result will be the inches of vacuum referred to a 30-in. barometer.

The following equation is used to correct the mercury column for changes in temperature:

$$H = H_0\,[1 - 0.000101\,(T_1 - T)]$$

where

H = height of mercury column corrected to standard temperature T.

H_0 = observed height of mercury column.

T_1 = observed temperature of mercury column.

T = standard temperature to which column is referred.

In the foregoing problem no temperatures have been stated, so we will assume the temperature of the mercury in the vacuum gage to be 80 deg. F. We will also assume that an aneroid barometer is used in which case no correction for temperature is necessary. Where a mercury barometer is used, the temperature correction is similar to that for the vacuum gage, which in this case is

$$H = 25.9\,[1 - 0.000101\,(80 - 58.15)] = 25.84$$

If there is no correction for the barometer then,

$29.27 - 25.84 = 3.43$

$30.00 - 3.43 = 26.57$ in. of vacuum referred to a 30 in. barometer.

IN A NUMBER of boiler plant installations the storage of fuel oil has been taken care of by the installation of concrete underground tanks provided with water seals. The interior of these tanks are covered with two coats of bitumastic paint.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Protection—For Criminals or for Honest Men?

Gradually people are awakening to the need for effective measures in dealing with the unprecedented amount of crime now in evidence throughout the country. Since realization of the need must precede action, this is gratifying, but the process should be accelerated.

Reliable statistics show that more violent crimes are committed in Chicago in a year than in all the British Isles. The reason is found in the diametrically opposed policies of the two countries in dealing with criminals. In England, if anyone kills another, the killer dies. It is the policy of "an eye for an eye." Whereas, if anyone commits a murder in Illinois, the chances are 900 out of 1000 that he will escape justice. We are getting the result. The idea that "you cannot rule by fear" breaks down before the figures for crime in England and in America.

Continuance of the policy labeled "humanitarian"—coddling criminals in nice, pleasant surroundings so that they can be "nursed back to mental health" is getting us nowhere in the struggle against the mounting record of crime. It is increasing the danger to honest citizens; it is increasing burglary insurance rates; it is slaying hundreds of innocent men and women; but it is giving no protection except to criminals who prey upon society. Severity, not sentimentality, is needed.

Should anyone doubt the efficacy of the "pay up" policy, let him study the figures of the Vigilantes—a body established through co-operative action of the Iowa banks. During the 12 months from June, 1924, to June, 1925, activities of this body reduced Iowa bank robberies from over $250,000 to less than $3000. Their motto is, "No work for the jury" and the basis on which they work is shown in the public offering of a reward of $2500 for a dead bandit, killed while robbing a bank, and $1000 for the conviction of a live one. Illinois banks are adopting the same policy and it is hoped to achieve like results.

Sentimentalism has been tried and found wanting. The law cannot deal effectively with crime until consideration for accused habitual criminals and convicted criminals is made secondary to protection of the law-abiding. Private agencies and vigilantes have been found necessary to control and punish crime. It is time we woke up and took steps to put teeth in the laws against crime so that these functions may be put back into the courts where they belong.

Experiments in Railroad Management Come High

If, for any cause,—unwise legislation, trial of government ownership, failure of private management or any other factor,—service should be delayed for 24 hr. on our railroads, it would cost this nation several hundred million dollars. The railroads, ordinarily, carry 3½ million tons of freight daily, which is tied up as non-productive capital while in transit. The railroads are temporary storehouses of an immense amount of wealth and shortening or lengthening the period of transit increases or decreases the time during which this wealth is idle.

Railroads are more than mere carriers. When they are moving freight with such dispatch and efficiency as at present, they are aiding the productiveness of our capital. It behooves us to "let well enough alone."

When thinking of the strike in the anthracite mines, it is well to remember a few figures. The strike has thrown 150,000 miners into idleness. The daily pay roll of the anthracite mines was $1,200,000, and each day the men lose that amount in wages. It is difficult to estimate the loss to railroad men and coal handlers in wages and business, but it is probably as much more. And all because an arrangement was not made to allow the mines to keep on working while a new contract was being made.

Corrosion—A Billion Dollar Concern

Nine hundred million dollars is the estimated annual toll on America by corrosion. 85 per cent of this enormous loss by decay is entirely unnecessary; at least such are the convictions of some of the most eminent engineers and metallurgists in the United States, the figures being reached by translating Sir Robert A. Hadfield's recent calculation into terms of dollars.

Small wonder there is a growing interest in the subject of corrosion, and a noticeable increase in discussion of ways and means to overcome that waste. In technical circles, the subject of corrosion and its prevention is arousing nation wide discussion and is giving rise to a great many articles.

There are a number of good reasons for this growing interest in the problem of rust, chief among which are those set forth in the opening paragraph. Another reason, however, lies in the fact that with our present rate of production of ingot iron, which is now in excess of 40,000,000 t. a year, unless some preventive measures are adopted, the annual destruction of metallic properties by corrosion will assume a total cost staggering to the imagination.

But already much has come from the increased public and engineering discussions. Theoretical points formerly disputed and practical issues that heretofore only formed the ground work for disagreement have, through sane discussion, been clarified to a degree where theory and practice can now work hand in hand, the result of which has been much splendid work by such men as McKay, Evans, Aston and Speller.

Through the efforts of these men and others partial solutions to the rust problem have already been discovered, so that it is now only a question of the cheapening of processes, and the adoption of the principles involved by the producers of metal, before it will no longer be necessary to galvanize wire, to coat sheet steel with zinc or tin, or to apply paint to steel structures, that the basic metals may be preserved from the destructive influences of corrosion.

We need a practical solution for the problem of rust and, knowing that in the past solutions for important problems have always been found when actually needed, there is every reason to believe that solutions for the

costly ravages of corrosion will be unearthed, now that the problem is being vigorously attacked from many angles.

There is great need for co-operation between industries, however. No industry exists today that is totally different from all other industries, or that is not related in many ways to every other industry. No man exists who cannot learn from his neighbor. No one is totally isolated, no business so "different" that it does not have points in common. The principal function of the technical journal is to disseminate the experiences of men in the field it covers to the entire industry. These experiences are picked up by other technical or class journals and carried to other industries. It is not necessary to go a-field to be of real assistance to other industries. By solving one's own problem, or aiding in its solution, the greater number are automatically served, if but the solutions or experiences are made known to your trade journal.

In the matter of corrosion, for instance—what has been *your* experience?

Company Dinners a Profitable Investment

Like CO_2 recorders or lubricating oil, company dinners, held periodically for department heads and foremen, are a source of real profit, if properly handled. Few appliances in the boiler room can effect greater economies than recording instruments which constantly indicate the percentage of carbon dioxide. Probably nothing gives as much value, per dollar, as lubricating oil. Yet in too many power plants the CO_2 recorder remains inoperative for want of repair and in nearly every mill or factory one hears the whine of dry bearings.

Many organizations now employ the monthly or semi-monthly company dinners as a means to hold round table discussions of plant problems or standards of practice. In most instances, these dinners are of constructive good to both men and management. But all too often such gatherings defeat their real purpose of creating loyalty and bettering methods. Too often they become a bore to the men and are continued only because "the boss says so."

There are many reasons for the possible lack of interest in what should be a most constructive and sought-after event. Probably the chief cause of failure, however, is the lack of entertainment at each dinner. In carrying forward company dinners where serious business problems are discussed, the saving element of entertainment is too often overlooked.

No good lecturer will talk for 60 or 75 minutes without the liberal use of humor. All meat without salt may be ever so sustaining, but few will find it palatable. If a little more humor could be injected into our churches, the attendance would be greater. The school teacher with a sense of humor is of far greater benefit to the children than the severe-lipped, straight-laced pedagog.

Only last Monday I was called upon to address a gathering of foremen and department heads in a large industrial plant. The attendance was remarkable, stated as 97 per cent. (Quite evidently the men had never heard me speak!) In commenting on the attendance, the general manager said: "We have this sort of attendance every time. And it has only been since the first of the year that the men have shown such interest." Asked the reason, he went on: "Last year we had our own cafeteria chef prepare the dinner. Now we hire the services of a catering concern at just double the expense. Then, too, since the first of the year we have been bringing in outsiders to lecture. Our meetings now consist of a *good* dinner, a forty-five minute lecture and a thirty-minute round-table. The procedure has tripled our expenses, but it has done the same for our attendance, while plant loyalty and good will has increased markedly. So far this year we haven't lost a single foreman or department head through resignation."

All of which, to my mind, was a very good little sermon on the conduct and possible value of periodic company dinners.

Opportunity for an Ambitious Benefactor of His Country

Much newspaper space has recently been devoted to the request of Leopold Schepp, aged 85, for suggestions as to the best method to make disposition of his large fortune and to the replies to that request.

Here is an open suggestion which, while it may involve rather too much activity for Mr. Schepp to undertake it personally, is an opportunity for someone in a like position to inaugurate a movement which will be of the greatest benefit to all future generations.

About the time of Mr. Schepp's request, the Forest Service of the Department of Agriculture issued a report disclosing the startling fact that during 1924, 29,000,000 acres of public and private forest land was swept by fire, with an actual money damage to standing timber in excess of $38,000,000. This amount was exclusive of the damage to young growth and the loss from water shed protection, to recreational facilities and to the harboring of wild life.

No single economic crisis today confronts this country which equals in importance the destruction of our forests. Reforestation is a vital necessity, and the factor that is lacking is a strong public sentiment favorable to reforestation plans. No political party has yet included such plans as a plank in its platform. No state has voiced a determination to put trees back on hills that are fit only for growing timber.

Before such plans can be made effective we must have favorable public sentiment and the guidance of such a sentiment is an object well worthy of the efforts of someone who has the millions and the time necessary to do the work.

Other objects of bequest are well taken care of. We have ample educational facilities, the Rockefeller Institute is pushing medical research to the benefit of humanity, charitable facilities are adequate, art galleries are numerous and other fields of philanthropy are well supplied with donors. Reforestation has had no outstanding effort expended on popularizing it. Attempts are being made to inaugurate reforestation but the experiments are few and scattered and the time is here when reforestation on a big scale ought to be started. This requires a strong and earnest public sentiment, to which political leaders will give heed. All parts of the country are suffering from diminution of forests through greed and ignorance of woodland owners and through preventable fires. Returning the woodlands to the hills would confer a blessing on every one of our millions of people. The opportunity awaits for some public benefactor.

EDITORIAL COMMENT

Burning the Nation's Fuel Economically

Much water will flow under the bridges of the world before we see an end of the competition between the isolated plant and the central station. As a matter of fact, had it not been for this same competition, we doubt whether the present-day central station, in some cases producing a kilowatt-hour with an average expenditure of 15,000 B.t.u. or less, would have been an economic success.

One aspect of the situation, however, is quite generally ignored by both central stations and individual plants in attempting to reach a decision as to which type of plant can best render the necessary power service in a particular case. Neither party to the controversy ever seems to consider that the whole question finally resolves itself into a consideration of the most economical utilization of the nation's fuel resources. Many industrial executives, we are sorry to observe, do not seem to care how much coal their plants waste. In many industries, the wastes in the manufacturing departments are so tremendous that a few thousand dollars wasted in the power departments form only a small proportion of the total waste.

Refusal by industrial plant engineers and industrial executives to face the facts is not half as bad, however, as their continual neglect to get the facts in the first place. It would seem, after fifteen or twenty years of agitation by the technical magazines and by engineers everywhere, that industry as a whole would be alive to its responsibility in this matter of economical coal-burning. Yet it is only when faced with the competition of the central station and compelled to decide whether or not to abandon his isolated plant, that the average industrial executive bestirs himself to attempt to find out how much his power costs him.

In the recent report of the power plant costs committee of the N.A.S.E., which is abstracted elsewhere in this issue, appear some actual records of power costs in various types of industrial plants. To our way of thinking, the principal benefits to be derived from publishing such data is that their publication may arouse other industries to do the same thing. It will help the central station, too, since it will provide a target to shoot at and an impetus to further economies in coal-burning. If the industrial plant discovers, after a careful, accurate and unbiased analysis of its power costs, that it can make power cheaper than it can buy it, no reasonable public utility will question its judgment. On the other hand, there are certain intangible advantages on the side of the central station that may make its service more desirable in that case. But a mere statement that a given industry can make its own power cheaper than it can buy it is not enough. That statement must be backed up by data of coal burned and the cost of steam and power generated, compiled from carefully kept records, before any dependence should be placed on it.

It is futile to pronounce judgment on a given situation until all the facts are available. Such a judgment cannot be classified as engineering but should be honestly recognized for what it is — mere guesswork or personal opinion, which has no place in power plant work. But if the publication of these representative power plant costs by the N. A. S. E. leads a few more industrial power plants to begin to wonder about their performance and take steps to gather some data on it, that labor of compiling the report will be well worth while. A study of this report will repay every industrial and central station engineer and will help him to attain the goal toward which the power plants of the nation should be always moving; namely, the consuming of national fuel resources in the most economical way.

American Leadership

European scientists and engineers have taught us many things in regard to the economical generation of steam and electric power. We owe a great debt to such men as Watt, Carnot, Rankine, De Laval and Diesel, whose works blazed the trail we have been following for several generations. They have given us mental tools with which to work and American engineers have perfected these tools, applied them to their industrial problems and built up a power generating system in this country that is the marvel of the world.

No longer is it necessary for the young American completing his education to travel in foreign countries for the purpose of observing the application of the most advanced ideas in power generation. On the contrary, prominent European engineers now find it profitable to come to America to study our methods with a view toward improving their own.

During this month a number of the noteworthy power plants of the country have as their guests seventeen eminent French engineers with a party of assistants and secretaries who are here to study the latest developments in steam power generation, distribution and utilization. As American industry grows in magnitude and its costs of production are reduced as a result of the application of scientific principles, we may expect more of these visits from foreign engineers. The World Power Conference has been a stimulus for the exchange of technical information which is bound to be of advantage to all the countries that participated. We Americans will undoubtedly continue to learn but should not be averse to teaching in exchange for the knowledge gained.

Another evidence of America's enterprise is its extensive use of electrical and mechanical appliances in its homes to lighten the burdens of the housewife and add to the convenience, comfort and health of the American people. Credit for this advancement in civilization is due largely to our public utilities in fostering the use of these appliances and to the enterprise of manufacturers who have placed them within the reach of nearly every home owner. Plans are now being made to give Europeans an

opportunity to witness, on their own soil, the comforts and luxuries now enjoyed in numerous American homes. This will be accomplished at the International Exhibition of Household Appliances and Labor Saving Devices to be held in Paris, where an American home, which has just been formally opened in Brooklyn, will be rebuilt for exhibition purposes.

America may still be too young a country to have to its credit a long list of fundamental scientific discoveries but American engineers can pride themselves on their leadership in the application of modern science to their industries and homes.

Off Duty

"Don't crowd, folks, just step this way—room for everybody. Pos-i-tive-ly the greatest collecshun of human freaks ever assembled on one spot. Here, La-dees and Gen-tul-men, for the small sum of twenty-five cents, only one quarter of a dollah, you will see Fah-Tee'-Mah, the world's fattest lady who tips the beam at 510 lb., side by side on the same platform with Professor Bostolo, the world's smallest dwarf. Step this way, La-dees and Gen-tul-men. See Jo Jo! Jo Jo, the dog-faced boy from Siam. Absolootly the only gen-yew-ine dog-faced boy in existence. See Bosco, the snake eater direct from Abyssinia—eats 'em alive! See Oliver Twist and Mlle. Pasquale, the three-armed lady from Madagascar. La-dees and Gen——."

It may have been years since you were inveigled out of a quarter into a side show but perhaps you remember Jo Jo; perhaps you don't, it doesn't matter. If you do you probably now harbor a sneaking suspicion that Jo Jo's dog face you gazed at in speechless wonder was nothing more than a papier mache mask cleverly hung over his own face. You may also recall the three-armed female from Madagascar and now, from a wider experience with a world of shams, realize, not without a tinge of regret, perhaps, that her third flapper was pure hokum. Time robs us of many youthful delusions.

Notwithstanding the fact that most of the freaks of the old time side show were manufactured freaks, there were usually some real ones. There are people with underdeveloped third arms, and there *are* human giants and dwarfs, and not all of them grace the side shows.

Now these people—these poor deformed and abnormal specimens of humanity, aside from the unwholesome form of curiosity they incite, are extremely interesting from a biological standpoint. Why are they deformed? What is the reason for the abnormalities of growth which make them objects of pity wherever they go?

Have you ever stopped to think about the reason these people grew into freaks, or, on the other hand, why most people do *not* grow into freaks? Has it ever occurred to you that it is quite amazing that during the period of your growth from childhood, the various parts of your body grew at a rate which kept them all in proportion? Why is it that at the time you reached maturity, your right and left arms stopped growing at the same time?

The mechanism of growth, we are told, is effected by the constant division of the body cells. A cell, during the course of its existence, develops and when a certain stage is reached, divides into two parts, each of which then acts as an individual cell. In time each of these halves splits up, making four cells. This continues until full growth is attained and then for some reason or other the cells stop growing. Until recent years the reason for this co-ordination between cell growth was a mystery but today biologists are pretty sure they understand its nature.

This is the day of glands. In the newspapers we read daily of new gland episodes — monkey glands, thyroid glands and whatnot. In our bodies we all carry certain ductless glands which it has been discovered are the source of certain secretions, chemical compounds, which are necessary to our well-being. These secretions are poured directly into the blood, reaching every part of the body, and act as regulators, controlling not only cell growth, metabolism and other vital processes, but also, we believe, are responsible for the differences in our personality.

It is because of these harmonizing secretions, hormones they are called, that we don't all develop into Jo Jos with dog faces. They co-ordinate the growth of the various members of our bodies so as to make us normal individuals. It is not just a happy coincidence that both of our ears or both of our legs stopped growing at the same time; it is because of the hormones. Any abnormal or subnormal activity of the hormone-producing glands results in a variation from normal in the physical or psychical makeup of an individual.

So when you bump up against a chronic grouch, don't be too severe in criticizing his disposition. He is not responsible. His hormones make him what he is. The same is true of your enthusiastic friend whose restless activity wears on your nerves; his trouble is an over-activity of the thyroid gland. What both of them need is not a lecture on good manners but a change in the environmental conditions affecting their hormones.

Perhaps the most interesting part of this hormone business which has fascinated biologists during the past few years is that it gives us a clue regarding the nature of cancer. Cancer, considered from the viewpoint of the hormonologist, is nothing but cell growth running wild. Some disturbance in certain hormone-producing glands causes a difference in the secretions necessary to regulate and control the growth of the cells and, with the restraining or guiding influence removed, the cells grow wild. Cancer, then, is not caused by a germ as has been thought, but by a disturbance from normal in the secretions controlling cell growth. Restore the qualitative and quantitative balance of these hormones and you have the cure for cancer. Is hormonology worth while? Well, we guess, yes.

The Background of the Vertical Pronoun

While he was vice-president of a great corporation he was visited by three college graduates. They were in search of a starting position. Having nothing to offer, he wrote each one of them a letter of introduction to business friends, soliciting consideration in their behalf. Written on company letter-heads, he signed the letters as "Vice-President." Each of the boys found work.

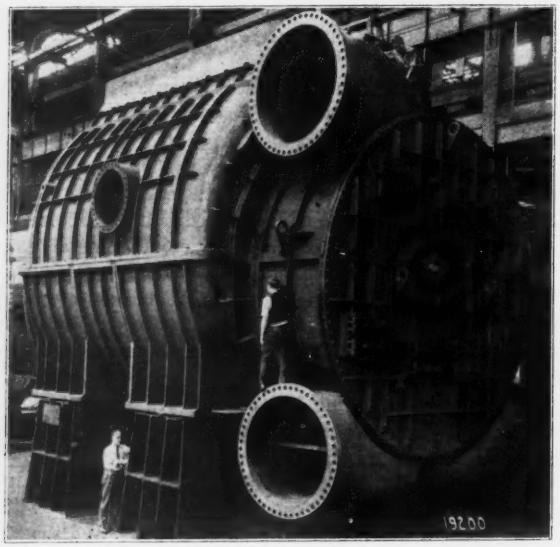
Three years later he retired. Came then an old schoolmate. A worthy fellow, capable and well respected, but fallen upon misfortune. The ex-vice-president wrote two score of his former business associates in behalf of the man he knew to be tried and proven. Courteous replies came, but no action. He was without the backing of his corporation.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Large Surface Condenser for Philadelphia Station

IN THE ACCOMPANYING illustration is shown a view of a large surface condenser recently completed at the South Philadelphia Works of the Westinghouse Electric and Mfg. Co.

The condenser, which it is claimed is the largest ever constructed, weighs almost one million pounds and rises



70,000 SQ. FT. SURFACE CONDENSER FOR THE NEW RICHMOND STATION

to a height of nearly 30 ft. It is to be installed in the new Richmond Station of the Philadelphia Electric Co. and will be capable of circulating approximately 150,000,000 gal. of water per day. This, it may be of interest to know, is equivalent to half of Philadelphia's daily water consumption of 300,000,000 gal.

The main condenser has a cooling surface of 70,000 sq. ft. in a frame of 85,000 sq. ft. capacity. Inside the shell, which alone weighs considerably above half a million pounds, are a total of 12,734 one-inch tubes, 21¼ ft. in length.

Part of the condenser equipment consists of two circulating pumps, each with a maximum capacity of 78,000 gallons per minute, or 4,660,000 gal. per hr. If, however, both pumps are operated simultaneously, their joint capacity will be 100,000 gal. of water per min., corresponding to 6,000,000 gal. per hr., or a total of 144,000,000 gal. every 24 hr.

To operate the two circulating pumps, the condenser when erected will be equipped with two 500-hp. motors.

The work of dismantling the huge piece of machinery is now under way, preparatory to shipping it from the South Philadelphia Works to the Port Richmond plant of the Philadelphia Electric Company. Almost a dozen of the heaviest type steel flat cars will be required for the transportation of the equipment from one point, around the city borders, to the place of installation.

An Adjustable Delivery Motor Drive for Alternating Current

AN INTERESTING development in the application of the alternating current motor to services requiring adjustable speed is seen in the Allis Adjustable Delivery Drive for alternating currents. This method of drive is applicable to any type of service which requires only that a constant average speed be maintained. In other words, it is applicable to those services in which a change in speed

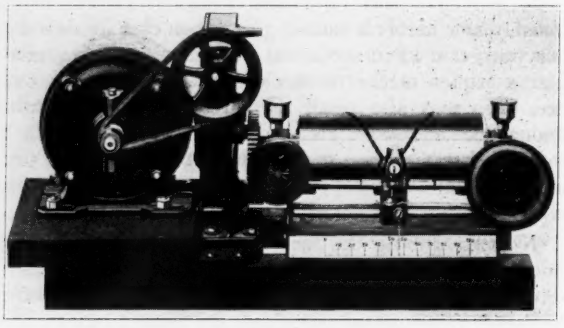


FIG. 1. THE CONTROL DRUM IS DRIVEN BY A SMALL ELECTRIC MOTOR

within a given interval is not objectionable, provided a certain average constant speed for that interval is maintained. During the past two years a number of these drives have been installed on stokers.

The drive consists of three elements, a multi-speed alternating current motor, a revolving drum for establishing the average speed, and contactors for switching the current to different windings in the motor.

The multi-speed motor is a machine of the squirrel cage type with two or more independent windings placed on the same core to give the proper number of poles and the consequent desired speed. They are usually wound for speeds corresponding to 6 and 12 poles on 60-cycle circuits, and 4 and 8 poles on 25-cycle circuits.

For controlling the speed of this motor, the control drum shown in Fig. 1 is provided. This, as will be noted, consists of a copper cylinder divided into sections, insulated by air gaps. The drum is rotated by a small motor and has bearing upon it brushes fixed in position, having one

such brush for each one of the windings of the multi-speed motor. There is, in addition, one adjustable brush, mounted on a slide which permits movement along the total length of the drum.

To understand the principle upon which this drive works, the diagram shown in Fig. 2 will be found convenient. This represents, for the sake of simplicity, a two-speed drum used in connection with a 600 and 1200-r.p.m. motor. This motor has two separate windings and will run at 600 or 1200 r.p.m., depending upon which winding is selected.

It will be assumed that the split section of the drum covers 6 in. of the length of the drum. A, B, C, D, and E indicate different positions of the adjustable brush. At A the motor runs at the minimum speed of 600 r.p.m. at all times. With the adjustable brush moved to the position B, the motor will run for ¾ min. on the 600 r.p.m. winding and for ¼ min. on the 1200-r.p.m. winding, giving an average speed of 750 r.p.m. With the adjustable brush moved to C, the motor will run for ½ min. on the 600-r.p.m. winding and for ½ min. on the 1200-r.p.m. winding, giving an average speed of 900 r.p.m. At D, the motor will run for ¾ min. at 1200 r.p.m. and for ¼ min. at 600 r.p.m., giving an average speed of 1050 r.p.m. At E, the motor will run at 1200 r.p.m. at all times. It is evident that between 600 and 1200 r.p.m. there are an infinite number of average speeds possible.

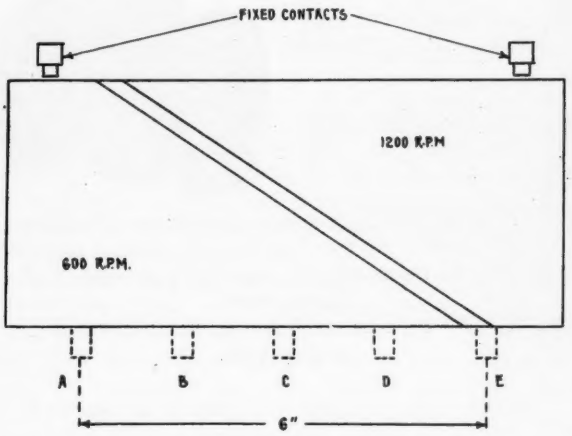


FIG. 2. DIAGRAM SHOWING PRINCIPLE OF OPERATION

The speed increase is directly proportional to the distance the adjustable arm is moved. While only a two-speed adjustment 2 to 1 ratio—has been described, the operation is fundamentally the same using three different speeds on a three-speed motor, such, for instance, as 600, 1200 and 1800 r.p.m. The control in such an instance would consist of a three-section drum as shown in Fig. 1.

By replacing the hand wheel of the adjustable brush with a small sheave pulley or sprocket, the average speed may be controlled automatically from a suitable source.

This device is manufactured by the Louis Allis Co., of Milwaukee, Wis.

MOORHEAD, MINN., City Light and Power Plant is planning the installation of two 300-hp. water-tube boilers and stokers, together with a new 750-kw. turbo-generator and all necessary auxiliary equipment and switchboards.

Automatic Weigher Gives Record of Boiler Water

CONTINUOUS record of the water fed to a boiler installation, with a record of coal fired, gives the most satisfactory check on boiler performance. A weigher which gives such a continuous record with an average error not over 1 per cent, as shown by tests, has been devised and is being marketed by John E. Runnells, Box 465, Worcester, Mass.

Installation at the Whithall Carpet Mills is shown in Fig. 1 where it has been giving satisfactory service since December, 1923. At the top is a hot water mixing tank from which water flows to the weigher, which, in turn,

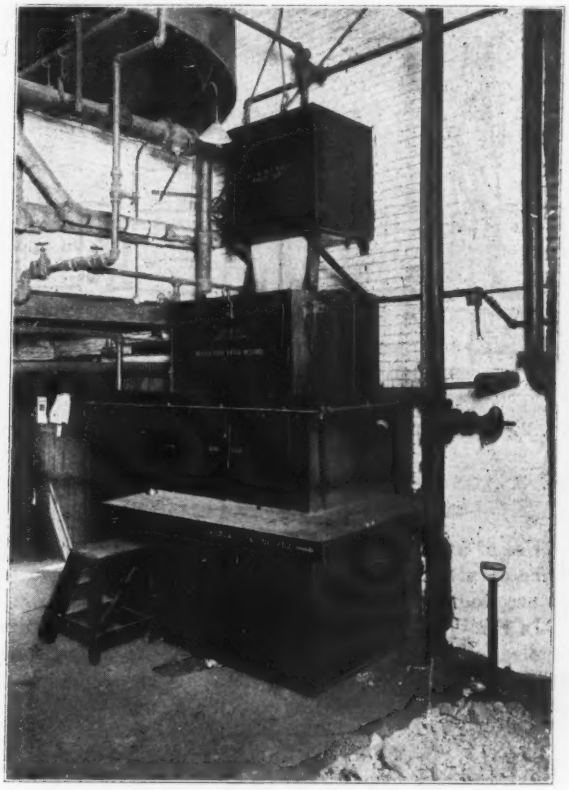


FIG. 1. BOILER FEED WATER IS RECORDED AUTOMATICALLY BY THIS INSTALLATION

delivers it to the sump tank below. Because of limited head room, the tilting trough of the weigher was placed below the top of the sump, which is a good arrangement as it takes care of any splash from discharge into the sump.

Construction of the weigher is shown in Figs. 2 and 3. It is double sided, one side being filled while the other side is emptied. The upper part, A, is a fixed rectangular tank, divided by a lengthwise partition. In each side is an overflow B and a main outlet valve C. Below this tank, a twin trough D is hung on a knife edge bar E, tilting of this trough opening or closing valves C and F. Valves of one side are opened when those of the other side are closed. On top of tank A a deflector H is mounted on a rock shaft which is connected by a bell-crank and link to one end of the trough D so that, when the trough tilts, it

changes the deflector from one side to the other, thus guiding the flow alternately into the two divisions of tank A.

With deflector as in Fig. 2, water flows into the left hand side of tank A, whose outlet is closed, until it reaches the top of the overflow, B, Fig. 3, when it will spill over into the trough D below. Meantime valves C and F of the right-hand side are open and water is discharging. When the left hand side of D is filled from the overflow, the trough will tilt on its knife-edge support and this closes valves C and F on the side which has been discharging, opens those valves on the side that has been filled and swings the deflector to its opposite position. Alternate fill and discharge are thus entirely automatic and go on with no attention whatever. A counter records each double dump, thus giving a record of the water passed by the weigher, when once it has been calibrated at the factory.

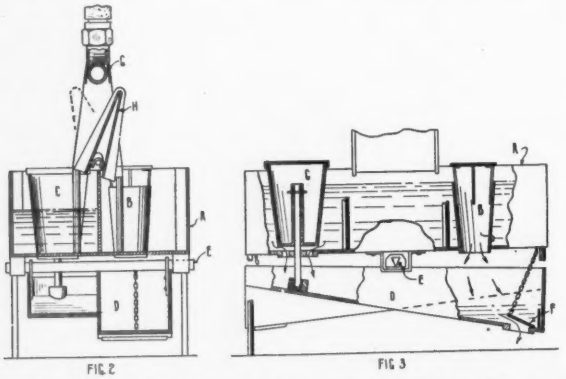


FIG. 2. TWO SIDES OF THE DIVIDED TANK ARE FILLED AND EMPTIED ALTERNATELY

FIG. 3. TILTING OF THE DIVIDED TROUGH OPERATES DISCHARGE VALVES AND THE DEFLECTOR

Use of a slotted pipe at G to deliver water in a sheet to the deflector gives a more satisfactory flow and reduces the necessary travel of the deflector.

In the Whithall plant, 2000 lb. of water a minute are handled, operation is unaffected by change in temperature from freezing to boiling and continuous service has been received with no stops during working hours.

This Plug Valve Turns in Lubricant

REQUISITES of a plug valve are that it shall turn easily, close tight and never stick. Not so easy, for a long taper forced into its seat fits mighty close, especially if it has stood for a long time in that condition. But fluid pressure on the small end can release it, lubricant can make it easy to turn and can seal the joint.

These are the principles embodied in the Merco Nordstrom plug valve made by Merco Nordstrom Valve Co., 121 Second St., San Francisco, Calif. The valve body has a lubricant chamber at the bottom of the plug. In the stem is a reservoir from which the lubricant is forced through a check valve to ducts in the plug, leading to the chamber below. A turn of the screw puts pressure up to 2000 lb., on the bottom of the plug, releasing it from the seat and forcing a film of the lubricant between plug and seat.

Tightness is insured by careful fitting and by a washer, asbestos packing and gland on top of the plug; the whole being kept in place by a yoke bolted to the valve body as in Fig. 2.

Another feature is a stop cast on the cover, limiting the motion to a quarter turn which opens or closes the valve completely, this stop being visible and showing which way to turn for opening or closing, but never allowing the lubricating grooves to be exposed to the fluid passing through the valve.

Special lubricants in cartridge form to fit the reservoir are furnished for various fluids to be handled such as alkaline or caustic solutions, petroleum products, acids, turpentines or hot water.

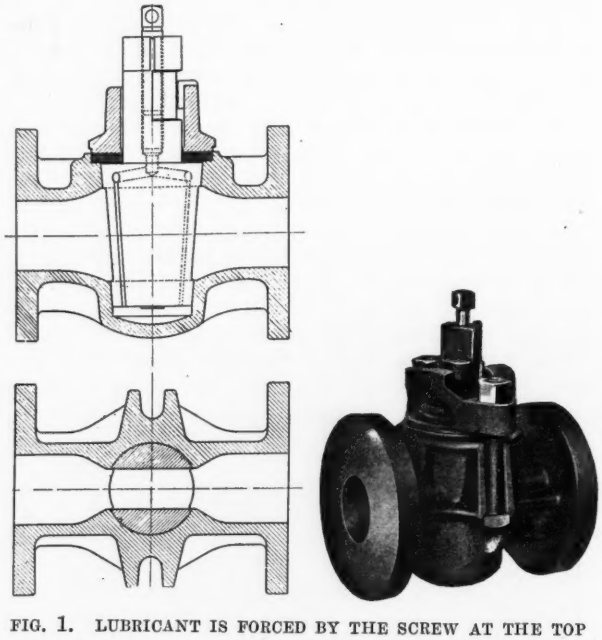


FIG. 1. LUBRICANT IS FORCED BY THE SCREW AT THE TOP THROUGH PORTS TO THE BOTTOM CHAMBER. OPENING THROUGH THE COCK AND BODY ARE DESIGNED WITH STREAM FLOW LINES

FIG. 2. THE COCK IS HELD IN PLACE BY A GLAND AND BOLTED YOKE

Flanged or screwed ends are furnished also special ends with loose split flanges in sizes from 1-in. to 16-in. and for 150 and 250-lb. pressure. Three-way and four-way valves are made on the same principle.

THE MINNESOTA COMMITTEE on the Relation of Electricity to Agriculture has completed a moving picture depicting the application of electricity to agriculture on the rural test line near Red Wing, Minn., the first line of its kind in the world. The picture was prepared under the direction of Charles F. Stuart, assistant to vice president and general manager of the Northern States Power Co., who is a member of the Minnesota Committee. A copy of the film is in the possession of the advertising department of the Byllesby Engineering and Management Corporation and will be shown on suitable occasions.

THE TIMKEN Roller Bearing Co., Canton, O., has issued an extremely useful set of data sheets giving the company's bearing recommendations for industrial applications.

Collins Safety Water-Tube Boiler

THIS DESIGN, which is of the ring circulation type, has a rectangular staybolted water leg at the front into which two of the banks of tubes are joined. This leg is also connected to the front steam drum so that steam made in the lower bank of tubes is liberated directly into the front drum and passes by the "overcomer" bank of tubes at the top to the rear drum from which steam is taken off. Water passes from the water leg through the upper bank of tubes to the rear drum where steam is also liberated, and returns to the bottom or mud drum through the right hand section of the vertical bank of tubes. Feed water enters the rear top drum at the entrance of the left hand section of the vertical bank and passes down through that section to the bottom drum, that section acting as a feed-water heater.

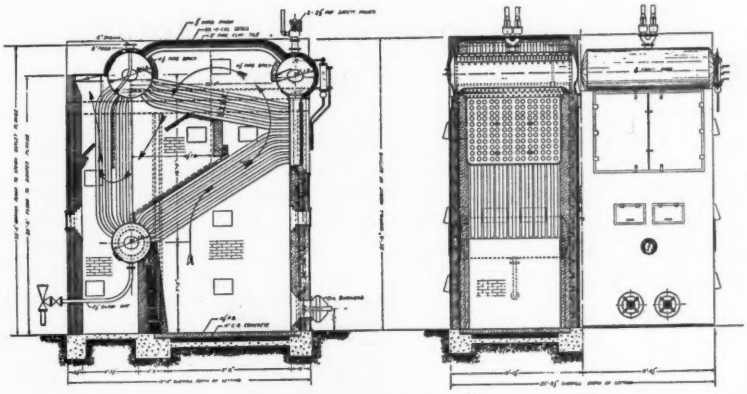


FIG. 1. COLLINS BOILER IS OF RING TYPE WITH VERTICAL FRONT WATER LEG OF RECTANGULAR SECTION

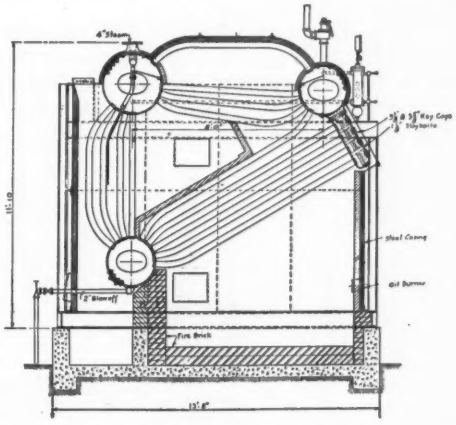


FIG. 2. FOR RESTRICTED HEAD ROOM, THE WATER LEG MAY BE SET INCLINED. HOLES CLOSED BY KEY CAPS ARE PROVIDED OPPOSITE TUBE ENDS

As explained by the designer, Glenville A. Collins, the lower inclined bank, which receives the greatest amount of heat, will generate approximately 70 per cent of the steam made by the boiler and this will be discharged at a tangent to the flow of the water into the front drum. It has three chances to get rid of entrained moisture; while passing through the front drum to the overcomer, by superheating in the overcomer bank and while passing downward and reversing its flow in the rear drum to get to the steam nozzle.

In the upper inclined bank, 30 per cent of the steam is made and is dissociated on reaching the rear drum, there mixing with the superheated steam from the overcomer bank, giving, it is stated, dry steam with a slight amount of superheat, which will vary with the rate of operation.

Heating of the water in the rear bank will result in the deposit of a large part of the solids in the mud drum whence they can be blown down.

Opposite each drum in the front wall of the water leg is a Key cap which does not require gasket or crab and can be knocked in by a wooden maul. This allows the cleaning of the two inclined banks of tubes from a platform in front and permits of starting the work while the brickwork is still hot.

Added power can be gained by increasing the width of the water leg and the length of the drums to allow of more tubes. Where head room is restricted, space can be saved by setting the water leg on an angle to the vertical as shown in Fig. 2.

Because of the rigid construction and complete joining of all parts, it is possible to hang this boiler by the upper drums from a steel frame, cover it in with a steel casing and thus make a portable boiler in sizes up to 80 hp. as shown in Fig. 3. Such a unit is said to have been transported 16 mi., set on a prepared foundation, stack erected and boiler placed in full operation in 9 hr. These units are capable of high overload operation, as is evidenced by the statement that a 80-hp. unit has been run at 270 hp. for several months without sign of disturbance in the water column, even with three gages of water showing.

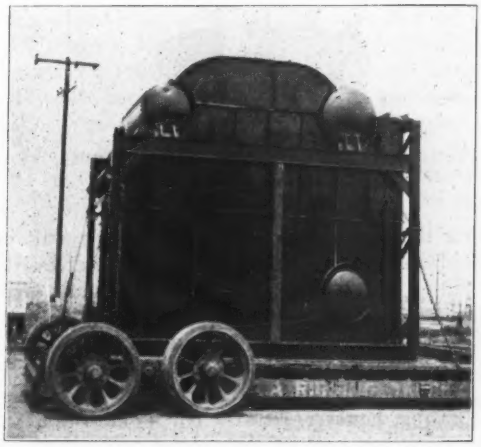


FIG. 3. COLLINS BOILERS CAN BE MADE IN FULLY PORTABLE FORM, THIS UNIT BEING OF 800 SQ. FT. HEATING SURFACE

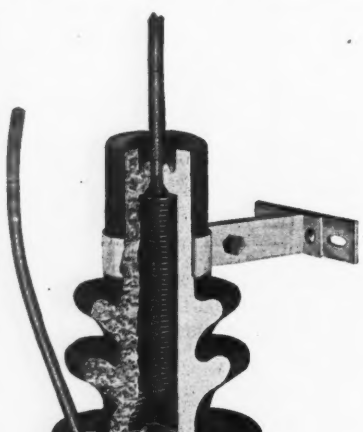
The Collins boiler is being built by the Southwestern Engineering Corp., of Los Angeles, Calif.

FOSTER ENGINEERING CO., Newark, N. J., at a recent meeting, elected new officers as follows: Charles A. Olson, president; Charles R. Emerson, vice-president; James T. Hayden, treasurer; G. S. Geortner, secretary and assistant treasurer. R. C. Anderson, formerly president, was made chairman of the board of directors.

New Safety Feature in Autovalve Arresters

ONE OF THE latest improvements in the Westinghouse type Autovalve Glow discharge lightning arrester presents a feature in conformity to the latest safety first practice. Ordinarily when a lightning arrester becomes crossed with high voltage lines or is struck directly by lightning, the insulator section explodes from the heat generated and heavy pieces of porcelain fall into the road, causing injury to any person or animal that may be in its path.

In the Autovalve Arrester, however, when subject to the excessive voltage of a direct stroke, the new arrangement, called a drop-out feature, eliminates entirely any chance of injury to a passerby. This safety feature consists of a very thin cross-section where the porcelain which



WESTINGHOUSE TYPE LV AUTOVALVE ARRESTER, SHOWING NEW SAFETY FEATURE

supports the resistance discs joins the side wall of the porcelain casing. The heat generated by the excessive voltage causes this part to expand more rapidly than the thicker section, thereby fracturing the thin wall and clearing the line by allowing the discs to drop out. The discs are comparatively light and could cause no injury to a person when falling to the ground. The heavy porcelain casing, however, remains on the cross-arm and the broken section is held on the ground lead.

Michigan City Plant to Have 600-Lb. Turbines

THE MIDLAND UTILITIES Co. of Chicago, Ill., has recently awarded a contract for power station equipment including two 31,250 kv.a. turbine generators and two 32,000-sq. ft. radial flow surface condensers with condensate pumps and air ejectors to the Westinghouse Electric and Manufacturing Co.

This equipment is to be used in a new station of the Calumet Power Co., a subsidiary of the Midland Utilities Co., and is to be located at Michigan City, Ind. A previous order received some months ago by the Westinghouse Co. includes power transformers, circuit breakers and instrument transformers to be used in the 132,000-v. switch yard of the new power station.

One feature which makes these units differ somewhat from the ordinary type is the 600 lb. throttle pressure and the 750 deg. total steam temperature at which the turbines operate. Attached to the same shaft of each main generator is an auxiliary generator of 2140 kv.a. rating at 2300 v., used to supply power for the station auxiliaries. There are also two direct connected exciters on the same shaft, one for the main generator and one for the auxiliary generator. There are, therefore, four electrical units driven by one steam unit.

Improvement in Diagonal Packing

ROD PACKING should do two things; maintain a tight joint around the rod yet rub the rod lightly so as to avoid friction. Alternate diagonal layers of rubber and soft-woven duck are found to meet these requirements; to fill every space by expanding with comparatively slight pressure, hence to give small rubbing friction.

HORIZONTAL FACING STRIPS HOLD THE DIAGONAL LAYERS IN PLACE

Tendency of small corners to split off and of edges of the diagonal layers to roll has been overcome in an improved type of diagonal expansion packing where the sides are faced by straight layers of duck and rubber which hold the diagonal layers in place, preventing stripping and rolling of edges. The construction is as shown and the improved form is made by Pioneer Rubber Mills, 345 Sacramento St., San Francisco, Calif.

News Notes

THE ADMINISTRATIVE BOARD of the American Engineering Council will hold its next meeting in Columbus, Ohio, October 29 and 30, under the auspices of the Engineers Club of Columbus. President James Hartness former governor of Vermont, is expected to preside. Chief among the topics to come before the Board is the study of commercial aviation now being made by the Council jointly with the Department of Commerce. Numerous reports of other activities of the Council will be presented.

ON OCT. 14 to 24, the 18th Annual Electrical and Industrial Exposition, will be held in Grand Central Palace, New York City. Among the exhibits will be displays by the Bureau of Standards, the U. S. Army Signal Corps, Radio Division of the U. S. Navy and Chemical Warfare Service of the U. S. Army. Many exhibits will have to do with progress in domestic use of electricity, an interesting feature being a new device which will permit of cooking and baking with the heat of ordinary electric light bulbs.

AT A MEETING in London, Eng., of the International Executive Committee of the World Power Conference it was decided to hold an interim sectional meeting at Basle, Switzerland, in 1926 in conjunction with the Exhibition for Inland Navigation and utilization of Hydraulic Power. It was decided that full conferences should be held at intervals of 5 yr., the next one being set, tentatively for 1930 in Rome. Also a Journal of the World Power Conference is to be published at regular intervals.

THE NORTHERN EQUIPMENT Co., Erie, Pa., announces the appointment of the Tennant Co., Houston, Tex., as representatives for Southern Texas.

DETROIT EDISON Co. has recently contracted with the R. H. Beaumont Co. for coal handling equipment to be installed in the Delray Station. The equipment includes two 200-cu. ft. skip hoists, automatically loaded by Simplex loaders. The hoists have a capacity of 200 t. an hour.

ANNOUNCEMENT is made by the Brown Instrument Co. of the opening of an office at 363 New High St., Los Angeles, Calif. S. F. Godfrey is the district manager and will carry a complete line of the company's products in stock as well as maintain a repair department for the convenience of customers.

DIAMOND POWER SPECIALTY CORP., Detroit, Mich., announces that the territory of the Lathrop-Trotter Co., 733 Union Trust Bldg., Cincinnati, Ohio, which has been its sales representative in the Cincinnati territory for many years, has been extended to take in Indianapolis and the adjacent territory in Central and Southern Indiana.

THE GENERAL GAS & ELECTRIC Co., New York, has completed the construction of the first unit of its new central steam-operated electric generating plant on the Broad River at Parr Shoals, S. C., to be operated by the Broad River Power Co., Columbia, S. C., a subsidiary organization. The station has been in course of building for a number of months past, and has a rated capacity of 17,000 hp. The plant will be used to supplement the Parr Shoals hydroelectric generating station of the company, with capacity of 20,000 hp. An extensive transmission system has been constructed for service at Columbia, Spartanburg and neighboring territory in Central South Carolina. Plans are being perfected for the installation of another unit of approximately like output at the steam station, and it is expected to proceed with the expansion at an early date. The complete project will represent an investment of close to $3,000,000.

TO ITS co-operative courses on electrical manufacturing with the General Electric Co., on station operation with the Edison Illuminating Co. of Boston, on transportation with the Boston Elevated Railway and on power plant design and construction with Stone & Webster, Inc., Massachusetts Institute of Technology, Cambridge, Mass., has added a course on telephone engineering in conjunction with the Bell Telephone System of New York City. The new course is open to students who have completed 2 yr. of regular work in Electrical Engineering and continues for 3 yr. more, leading to degrees of B. S. and M. S. in E. E. Four months each year are spent in the employ of the Bell System, with evening class work on electrical and cultural subjects and lectures by Bell Co. experts. The balance of the year is spent at Cambridge in regular class and laboratory work. Practical work covers manufacturing, installation, testing, operation, design and research, the students carrying on the work the same as other employes of the company, but are transferred as they master the various jobs. They are paid for their work, the total for the 3 yr. being approximately $1500.

ANNOUNCEMENT is made that the annual meeting of the A.S.M.E. in New York City will be from November 30 through December 4, an extension of one day.

ECONOMICAL STEAM GENERATION will be the subject of a talk by H. D. Savage before the Utah Section, A.S.M.E. at Salt Lake City on October 28.

DR. WILLIAM F. DURAND, president of the A.S.M.E. and noted authority on steam and marine engineering is serving on the Aviation Board appointed by President Coolidge and has been made secretary of the Board.

AT TULSA, OKLA., the Mid-Continent Section, A.S.M.E., will meet October 23, at 8 p.m. to discuss "Flow of Oil in Pipe Lines," with Wm. G. Heltzel, Dean Foster, H. Wright and V. C. Milliken leading the discussion.

AMERICAN SCHAEFFER & BUDENBERG CORP. has opened a "downtown" Boston office in the Chamber of Commerce Bldg., 80 Federal St., telephone, Liberty 2383, for the greater convenience of customers. U. H. Nickerson will be in charge as heretofore. Also, to secure improved facilities, the Boston plant is being transferred to Worcester, Mass., where full stock will be carried.

AT THE NEW YORK Power Show, Nov. 30 to Dec. 5, a series of lectures has been planned covering important developments in power and mechanical equipment during the past year. Topics selected include, Steam Prime Movers, Oil and Gas Engines, Steam Boilers, Industrial Power Plants, Hydraulic Machinery, Machine Tools, Heating and Ventilating Equipment, Refrigeration, Power Transmission, Materials Handling in Power Plants and Industries, Steam Locomotives. These will be so scheduled as not to conflict with writings of the A.S.M.E. and, combined with the opportunity to study the latest apparatus at the Show, will give an educational opportunity of the greatest value.

They will be supplemented by motion pictures showing industrial and engineering methods and achievement.

THE ALABAMA POWER Co., Birmingham, Ala., has secured a preliminary permit to proceed with the construction of its proposed hydroelectric power plant at Lock 18, on the Coosa River, near Wetumpka, Ala., and will place surveys under way at once for the construction of a branch railroad from the power site to a connection with the Louisville & Nashville Railroad, for the transporting of machinery and supplies. A power dam will be constructed to raise the present river level about 95 ft., providing a reservoir to cover an area of approximately 4800 acres. The volume of water to be stored, however, will be comparatively small, as the plant will operate on the "run of the river," in which the water flowing will be utilized as it comes or otherwise wasted. The power plant will be designed for a gross production of about 180,000 hp., and machinery and equipment to be installed will be purchased in the near future. All construction work, including equipment installation, will be carried out by the Dixie Construction Co., Birmingham, a subsidiary of the Alabama Power Co. The entire project is estimated to cost in excess of $10,000,000.

Books and Catalogs

FAN ENGINEERING, second edition; edited by Richard D. Madison and Willis H. Carrier, 612 pages, 4½ by 7 in., illustrated, price $4.00, Buffalo, N. Y.

Those who are concerned with fans and their applications will be interested to learn of the second edition of "Fan Engineering," a handbook for the engineer, architect or student dealing with centrifugal and propeller fans, their properties and applications in the arts and industries. The first edition of this volume was published in 1914 by the Buffalo Forge Co., Buffalo, N. Y., and edited by Willis H. Carrier. In 1920 a second printing was found necessary and the present edition, edited by Richard D. Madison under the direction of Willis H. Carrier, is a thorough revision and brings the book completely up-to-date regarding data, general practice and apparatus. In preparing the material for the second edition special effort has been placed upon its general arrangement so that a subject can be readily located and the desired information at once obtained. The book is therefore divided into three parts. The first part deals with the physical properties of air, heat and humidity, the flow of air in general and as regards the fan and systems of air distribution in particular. Part II relates to the application of air and air movements to the various classes of work for which fans may be adapted. This part has been rewritten to include valuable research data and current practice in the arts of heating, ventilating, air washing, drying, mechanical draft, exhausting and conveying and miscellaneous other applications. Part III opens with numerous examples of selection of fans and heating and ventilating apparatus, followed by a section on materials, stresses and balance. The remainder of this part contains performance tables and general information concerning fans and fan system apparatus.

INCREASED ATTENTION is being directed to sales promotion, sales research and statistics, and sales training, according to the survey just completed by the Policyholders' Service Bureau, of the Metropolitan Life Insurance Co.

"Tendencies in Sales Organization," the third Management leaflet, describes the organization and functions of sales organizations in such nationally known companies as the American Radiator, the Fuller Brush, the Elliott-Fisher and the Burroughs Adding Machine Co. A comprehensive chart on the last page gives the outline of these organizations at a glance.

Any interested executive may obtain a copy, gratis, by writing to the Policyholders' Service Bureau of the Metropolitan Life, New York City.

"IS HAND FIRING LESS EXPENSIVE?" is the title of an interesting booklet gotten out by the United Stokers Co. of La Porte, Ind. Its purpose is stated to be to tell the plant operator something about lowering the cost of making steam in plants of from 80 to 350 hp. The point is made that the less it costs to produce steam, the more valuable it becomes as it means more chance for profit and low cost does not mean poor quality. The booklet tells of the S type stoker, its construction and results from its use. It is well worth the attention of readers.

ANDREWS-BRADSHAW Co., Pittsburgh, Pa., has recently issued, in pamphlet form, for distribution among engineers, a paper read before a meeting of the National Electric Light Association on the "Physical Side of Concentration in Boilers" by Roger W. Andrews.

REPUBLIC ELECTRICAL level and pressure indicators and recorders for showing head and tail water levels in water-power plants, levels in water and oil tanks and pressures in pipe lines for liquids or gases are described and illustrated in an attractive folder recently issued by the Republic Flow Meters Co., 2224 Diversey Parkway, Chicago, Ill. In these meters, the pressure on a column of mercury in a U tube forces a rise in the other leg which, by means of contacts cuts out resistance in an electrical circuit and thus changes current flow in proportion to the pressure. Meters showing and recording current flow can, therefore, be calibrated to show the pressure on the U tube.

Copies of the folder may be had by writing to the Republic Flow Meters Co.

ENDLESS BELTS, a booklet which has just been issued by the L. H. Gilmer Co., of Philadelphia, contains engineering data on small belt drives, including discussions of belt speeds, ratio of pulley diameter to belt thickness, pulley flanges, crowning, take-up, etc. In this compilation of data specifically applying to small belt drives, much of the information contained has been worked out in the L. H. Gilmer Co.'s research laboratories and is now printed for the first time. The booklet is illustrated with numerous photographs showing small belts of exceptional character.

WAGON LOADERS, portable flight and belt conveyors, chutes, rotary screens and other equipment for handling coal into and out of storage and in the plants of coal dealers and users are fully described and illustrated in the 100-page catalog, No. 725, recently put out by Gifford-Wood Co., Hudson, N. Y.

Quick and economical handling of coal and ashes is an effective way to reduce plant costs and labor, hence the devices shown will be of interest to Power Plant Engineering readers, who can get the catalog on request to the Gifford-Wood Co.

ST. MARY'S DIESEL Oil Engines is the title of a catalog which illustrates clearly the details of this engine in one, two, three and four-cylinder types. It gives also a list of sizes and a table showing the comparative cost of power of different amounts as furnished by a Diesel engine, a gasoline engine, a gasoline-kerosene engine, an electric motor and steam power. The catalog is issued and will be sent to subscribers to Power Plant Engineering who request it by the St. Mary's Oil Engine Co. of St. Charles, Mo.

CENTURY POLYPHASE MOTORS, made in sizes from ¼ to 75 hp. by the Century Electric Co. of St. Louis, Mo., are described and fully illustrated in Bulletin No. 38. One feature to which attention is called is the wool-yarn system of lubrication for fractional horsepower motors to ensure long time service without reoiling. The bulletin is available on request to those interested.

RELIANCE STEAM SPECIALTIES, developed especially for the new demands of high-pressure boilers, are shown in detail and fully described in Catalog N recently issued by the Reliance Gauge Column Co., 5932 Carnegie Ave., Cleveland, Ohio. A copy may be obtained by request to the above address.

THE AUTOVALVE LIGHTNING ARRESTER is the title of Circular 1737, recently published by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. This pamphlet outlines the general principles of lightning protection, then goes into the details of the design of the Autovalve arrester.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Everyday Working Tools

Throughout the world there is a more general and growing appreciation of what power can do for mankind.

Communities are quick to recognize that power is a determining factor in building homes, industries, business and general prosperity.

Great and small industrial enterprises let it be known when they have the advantage of low-cost power. Customers and prospective customers realize its importance in the values they receive in products.

Bankers recognize it as a fundamental asset and workers are more loyal and confident of the permanent success of a business which has economical power available.

In this era of internal progress and external opportunity, there is no reasonable limit to what men of ability, ideas and energy may accomplish.

Accurate information and sound judgment are at a premium.

Nor is there time nor place for small-minded men, for bickering and hesitancy.

Particularly is this an era of carefully planned action, for progress in theory calls for progress in application.

Manufacturers of power plant equipment, machinery and supplies have been keeping their products apace with scientific advance and the practical requirements of plants of all sizes and kinds.

Economies developed in large units are being made available for small units. Efficiencies obtained under one set of conditions have been worked out for other conditions.

Men responsible for successful power generation recognize that the time has passed when the important part of their job is to see how long they can go without improvements.

Instead they are studying the whole range of improvements in methods and equipment to see what are available for their plants and how soon they may be put to work earning dividends.

This is the true American spirit of enterprise which makes this nation the one nation of the world most favorable to the pursuit of happiness and prosperity.

In the next quarter-year there will be presented to power plant men most unusual opportunities to equip themselves still further for leadership.

Two great power shows will bring together the men who buy for and operate power plants and the men who design and manufacture the machinery and equipment they are to operate.

Six Feature Numbers of Power Plant Engineering will make these contacts at the power shows closer and more valuable and will supplement them with the permanent ones which are made through the printed page.

Besides the editorial information on the New York Power Show to be given in the Nov. 15 and Dec. 1 numbers of Power Plant Engineering, the advertising pages of these issues will contain more specific information on the products of leading manufacturers.

In the Dec. 15th Annual Review Number and the Jan. 1 Reference and Textbook Number on "Boiler Plant Operation" will be found the responsible declarations of manufacturers to the men to whom they are in turn responsible for the success of their businesses.

Jan. 15 and Feb. 1 advertising in Power Plant Engineering will prepare its readers to get the most from the Chicago Power Show and make this exposition of even greater value in their daily problems.

To buy or not to buy is no longer the question in the power plant field. Every engineer recognizes that he must buy sooner or later every product that will improve his production of power.

How to buy and where to buy it are questions that are thrust forward for decision almost every day in the power plant.

Nor is the importance of these buying decisions necessarily related to the size of the plant or the cost of the items to be purchased.

A boiler in a small plant is often more vital to service and the plant for which it is to generate steam than a boiler in a large plant, and the service of a steam valve or stoker drive is as essential as the greatest generator unit.

No improvement in theory can turn its potential millions in savings into actual savings until men have designed, tested, constructed and put into place every piece of machinery and equipment down to the last joint and nut that makes that theory an operating reality.

In this light study the advertising pages of Power Plant Engineering, containing the latest information on tried and proven products and the direct statements of the men who manufacture to the men who use the machines and equipment that make power.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allen & Billmyre, Inc., New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Murray Iron Works Co., Burlington, Iowa.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR FILTERS.
Allen & Billmyre, Inc., New York.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Amer., Chicago.
Hagan Co., George J., Pittsburgh.
United Conveyor Corp., Chicago.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyor Corp., Chicago.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH TANKS.
Conveyors Corp. of America, Chicago.
Hagan Co., George J., Pittsburgh.
United Conveyor Corp., Chicago.

BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.

BEARING METAL.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.
Flexible Steel Lacing Co., Chicago.

BELTING.
New York Belting & P'k'g Co., New York.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills, McCanna Co., Chicago, Ill.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McLeca & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 148

BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE.
Allen & Billmyre, Inc., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg & Flue Brush Mfg. Co., St. Louis, Mo.
Sherwood Mfg. Co., Buffalo, N.Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Allen & Billmyre, Inc., New York.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
McLeod & Henry Co., Troy, N.Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw.

BREECHINGS.
Littleford Bros., Cincinnati, O.

BRUSHES, DYNAMO AND MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, O.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
McLeod & Henry Co., Troy, N. Y.
Pilbrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.

CIRCUIT BREAKERS.
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The Hartford, Conn.
Sherwood Mfg. Co, Buffalo.

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.